# final report

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# Demonstration projects for on-farm practical methane management strategies: Trevenna

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## Abstract

The 'Trevenna' on farm demonstration site in collaboration with MLA and the Australian Government's Climate Change Research Program - RELP was set up to build an integrated reference data of all major carbon flows in current and potential future sheep grazing systems (soil, animal, plant, air). Farmers, scientists, and students have participated in 49 events in the last 2 years, with over 2,000 people hearing about the project and over 550 people visiting the 'Trevenna' site. This project demonstrated how to estimate methane ($CH_4$) emissions and practical management for reducing emissions intensity. The FTIR spectrometer estimate of $CH_4$ emissions were 19.5 and 17.5 g $CH_4$/animal/day on high (HPL) and low productivity landscapes (LPL), respectively. Nitrous oxide emissions ($N_20$) were 4 times higher on the HPL than the LPL 20 *v.* 5 µg $N_2O/m^2/h$ in autumn, but 13 times higher on HPL in winter when the C4 plant species was dormant on the LPL.

## Executive summary

This project is one of four national sites across Australia to support the transition of outcomes of the applied research and development activities in the Reducing Emissions from Livestock Research Program (RELRP) through to demonstration of practical commercial abatement applications. A major objective of the Trevenna, University of New England, Armidale site was to build up integrated reference data of all major carbon flows in current and potential future sheep grazing systems (soil, animal, plant, air).The on-farm data collected was used to estimate methane emissions using FarmGas, SGS, and GrassGro (results reported in project BCCH 1039). It was intended to use the site as a regional reference point for effective integration of farm carbon, productivity and economic understandings. This project demonstrated: (1) how to estimate methane ($CH_4$) and (2) a 'do now' farm management strategy where emissions estimated over 50 years of historical data were measured as per unit product (results reported in project BCCH 1039). Farmers, scientists, and students have participated in two field days where scientists from UNE and NSW DPI 'got out of the lab' and 'into the paddock' to demonstrate the latest research and technologies that are available and demonstrate a 'do now' farm management strategy. The site has been an important 'hub' assisting 30 different groups (visitors, students, overseas visitors, landholder groups and industry representatives) increase knowledge and understanding of carbon flows. Discussions about carbon flows have occurred on a number of occasions.

The 'do now' farm management strategy was set up over two years to compare sheep productivity and emissions of low productivity (i.e., low fertility on the hills; 3.7 DSE/ha) and high productivity landscapes (i.e., high soil fertility enterprises on the more fertile alluvial flats; 6.7 DSE/ha). An EM38 soil map and seven soil samples were used to characterise the soil diversity within the two landscapes and to block each landscape into three classes (A, B, C), with three paddocks/class. Monthly pasture (green and dead DM availability) and regular production data (liveweight gain, fat score, fecundity, wool and lamb carcass weights at slaughter) were collected. Botanical composition, ground cover and herbage mass were assessed each season in pre-determined sites. In addition pasture samples investigating quantity and quality were taken at entry and exit of sheep from each paddock. Scans of pasture quadrats using a Crop Circle scanner (Holland Scientific equipment model ACS210) were taken before the quadrat was cut to determine actual green and dead biomass. The Crop Circles Normalized Difference Vegetation Index (NDVI) were correlated with the actual green biomass to assist in calibrating the Crop Circle scans. Each paddock was scanned along transects either north/south or east/west using Crop Circle equipment attached to a quad bike. The use of the Crop Circle scans increased the accuracy of estimating total green biomass from the NDVI. A ratio between green and total biomass was developed so that dead biomass could be estimated from the green biomass predicted from the non-linear regression between green biomass and the NDVI.

*Results 2010/11*

In the first year the high productivity landscape produced heavier lambs (39.1 kg liveweight (LW); 2.86 mm fat depth ~ 18 kg carcass weight (CW)) compared with the low productivity landscape (34.9 kg LW; 2.23 mm fat depth ~ 15.7 kg CW). In March 2011 the fourier-transform infrared (FTIR) spectrometer technology was set up (a collaborative project with BCCH 1036) and demonstrated at the March 2011 field day. The results from a study rotationally grazed across 2 paddocks and 2 allocated areas each of 1335 $m^2$ per landscape (i.e., 4 areas of the same size that were rotationally grazed on in each landscape) over 4 days (results reported are the average over 4 days) indicate that with 16 ewes and 15.5 lambs grazing for 1.95 days on the low productivity landscape and 32 ewes and 31 lambs grazing for 1.75 days on the high productivity landscapes that 19.5 g $CH_4$/animal/day were emitted from the high productivity landscapes and 17.5 g $CH_4$/animal/day were emitted from the low productivity landscape. Green biomass (kg DM/ha) was 3837 kg DM/ha (42% legume) and 1416 kg DM/ha (7% legume) for high and low productivity landscapes, respectively; digestibility's of green biomass were 65.8 and 54.0 % for high and low productivity landscapes, respectively. Dead biomass (kg DM/ha) was 922 kg DM/ha and

3246 kg DM/ha for high and low productivity landscapes, respectively; digestibility's of dead biomass were 54.8% and 47.0% for high and low productivity landscapes, respectively.

On average, nitrous oxide emissions ($N_20$) were 4 times higher on the more fertile and high productivity landscape (i.e., flats) (20 µg $N_2O/m^2/h$) than the low productivity landscape (i.e., less fertile hilly country) (5 µg $N_2O/m^2/h$) in autumn, but 13 times higher (13 µg $N_2O/m^2/h$) in winter when the C4 dominated pasture species on the hills (1 µg $N_2O/m^2/h$) were dormant. As mentioned above the high productivity landscape generally had more legume than the low productivity landscape which may have contributed to this result.

*Results 2011/12*

Ewe production rates for twins at the beginning of year 2 were 13% units higher than the low productivity landscape (37 vs. 24% for high and low, respectively). In the second year the high productivity landscape lambs were 1.2 kg heavier than low productivity landscape lambs on 5th December 2011 but this dissipated due to unusually high rainfall events. High rainfall caused flooding on the high productivity landscape and ewes and lambs were removed from the landscape 4 weeks before the end of the trial. Due to the flooding lamb weights on the high productivity landscape were lower than expected; the high productivity landscape produced lighter lambs than the low productivity landscape (37.0 kg vs. 38.1 kg LW) and (2.10 mm vs. 2.15 mm Fat depth).

*Field day results*

As at 1st March 2012 2,042 people have heard about the Trevenna site either through presentations at conferences or field days at other sites and 566 people have visited the site. In March 2011, 71 landholders, researchers and industry representatives attended a Trevenna field day, the evaluations (n=28) revealed that 74% were confident as a result of the day to change their $CH_4$ emissions through different management techniques; 95% said they could improve production efficiency/reduce emissions intensity on their farm; and 5% said that they have already reduced paddock sizes to allow for rotational grazing and that 50% of their property had some tree cover.

*Conclusions*

A 'do now' management strategy in improving pasture productivity has potential benefits in reducing the amount of $CH_4$ emitted per unit of product (results from year 1). The field days have provided a valuable forum to demonstrate methods to estimate $CH_4$ emissions. Farmers, researchers, and students have gained knowledge in how $CH_4$ is measured, and 'do now' abatement applications. The collection of data on soils, animal productivity, plant, and air emissions at the Trevenna site will be a valuable source for future referencing and running simulation models.

*Recommendations*

This study found that producers did benefit from the 'Trevenna' demonstration site. A recommendation from the study is that Trevenna should continue to run as a demonstration site and continue to collect relevant data related to green house gasses (GHG). As new practical commercial abatement applications become available Trevenna can therefore continue to demonstrate these applications to producers on the Northern Tablelands of Australia. Methods for estimating $CH_4$ in the paddock still need further development and again methods for estimating $CH_4$ can be demonstrated so that producers continue to get the latest information. The refinement and development of rumen models will also: (a) assist researchers understand the mechanisms associated with how $CH_4$ is produced in the rumen; and (b) improve the estimation of $CH_4$ that simulation packages and inventory models predict. The 'Trevenna' site has become a valuable research hub for GHG emission studies. The site could provide an ideal facility for Australia to train developing country scientists in GHG measurement and management as a national strategy of action within the Global Research Alliance. The future funding of this site will have lasting benefits to research in the area of GHG gasses. It would then continue to develop as a focus for information and understanding by landholders, land managers and researchers as the carbon market emerges. The research into GHG gasses is still a young science and demonstration sites that can be linked with 'out of the lab into the paddock' research will have a lasting benefit for the future challenges that the agriculture community faces.

## Table of contents

## Background

Agricultural emissions (methane ($CH_4$) and nitrous oxide ($N_2O$)) comprise 16% of Australia's total emissions, and livestock emissions (enteric fermentation and manure management) contribute 69% of agricultural emissions (Department of Climate Change and Energy Efficiency 2010). While there is no intention to directly include agricultural emissions in a future national emissions trading system, downstream penalisation on agricultural commodities is feasible and, more favourably, there may be opportunity for mitigation of agricultural emissions to provide a carbon offset market (Australian Farm Institute 2010).Therefore an increasing need exists to provide information to livestock producers including estimates of on-farm emissions and opportunities for on-farm emissions mitigation.

In collaboration with Meat and Livestock Australia and the Australian Government's Climate Change Research Program, the national "Reducing Livestock Emissions Program" has established four sites across Australia to demonstrate potential mitigation strategies for enteric emissions. These are: sites for beef and dairy emission mitigation in northern Queensland and Victoria respectively, and sites in Western Australia and in Armidale on the Northern Tablelands of New South Wales for sheep production. This project reports the results obtained from the 'Trevenna' Armidale demonstration site for sheep production on the Northern Tablelands of New South Wales. Field days have demonstrated to New England graziers the magnitude of sources and sinks of greenhouse gas emissions in a sheep grazing enterprise. The demonstration site has been established to equip producers with the knowledge, tools and strategies to manage and understand their on-farm sheep production emissions. The site will also provide training for undergraduate and postgraduate students in measurements of animal production, soil properties, and the use of whole-farm system models. The site is a regional reference point for effective integration of farm carbon, productivity and economic understandings.

## Project objectives

1. To support the transition of outcomes of the applied research and development activities in the Reducing Emissions from Livestock Research Program through to demonstration of practical commercial abatement applications.

An objective of the Trevenna initiative at University New England is to build up integrated reference data of all major carbon flows in current and potential future grazing systems (soil, animal, plant, air) for the purpose of:

- Picturing the relative scale of components of carbon (C) cycle and contribution to net farm emissions for farmers, scientists and policy makers
- Providing on-farm data for comparison with national greenhouse accounts and modelled farm emissions
- Evaluating mitigation strategies & their economic impact
- Providing integrated data for whole farm carbon balance & for Life Cycle Assessment of products
- Creating industry-specific and regional-specific hubs for gaining and disseminating knowledge
- Providing a core contribution to global knowledge

## Methodology

A 36-hectare demonstration site at Trevenna, University of New England, Armidale on the Northern Tablelands of New South Wales was established to give livestock producers a practical insight into the magnitude of carbon fluxes, especially methane ($CH_4$), associated with crossbred lamb production. A replicated study over two years was established to compare animal productivity and emissions of low (3.7 DSE/ha) and high (6.7 DSE/ha) productivity landscapes. An EM38 soil map and seven soil samples were used to characterise the soil diversity within the two landscapes and to block each landscape into three classes (A, B, C), with three paddocks/class. Actual monthly pasture (green and dead

DM availability) and regular production data (liveweight gain, fat score, fecundity, wool and lamb carcass weights at slaughter) were collected. Botanical composition was collected and a Crop Circle (Holland Scientific equipment model ACS210) scanner was used to calibrate the actual green pasture biomass. A non-linear regression was developed to estimate the green biomass from the scanned Normalized Difference Vegetation Index (NDVI). The Crop Circle scan attached to a quad bike scanned the paddocks on a monthly basis to determine the green biomass. Data collected from the 1st year (10th Sept 2010– 4th April 2011) was used to estimate total on-farm $CH_4$ emissions, emission per unit product, using SGS, GrassGro and FarmGas (results from the simulations and calculations in FarmGas are reported in BCCH 1039 "Managing carbon in livestock systems: modelling options for net carbon balance (UNE/I&I NSW)**"**. Fourier-transform infrared (FTIR) spectrometer technology was used over a 3 week interval in 2011 to determine actual $CH_4$ emissions. Actual water holding capacity and nitrous oxide ($N_2O$) measurements were also made during the trial. It is intended to use the site as a regional reference point for effective integration of farm carbon, productivity and economic understandings.

# Methods

## Plant, soil and topographical features of the site

The 36-hectare demonstration site 'Trevenna', is located at the University of New England on the Northern Tablelands of New South Wales (latitude 30° 30′ S, and longitude 151° 40′ E). The Northern Tablelands has a summer-dominant rainfall and an elevation of 1000 plus metres. The existing pasture was dominated by summer growing natives such as red grass (*Bothriochloa macra*), yearlong natives (*Austrodanthonia spp.*, *Microlaena stipoides and Poa spp.)* and introduced cool season species such as Ryegrass (*Lolium spp*.), Broomes (*Bromus spp*.) and Paspalum (*Paspalum spp*.). There were also some legume species present such as Subterranean (*Trifolium subterraneum*), Red clover and White (*Trifolium repens*) clover.

The site has two distinct topographic landscapes (tougher hill country and fertile creek flats) that are being used to differentiate grazing systems into low and high productivity systems appropriate for the topography. An electromagnetic induction soil survey was conducted of the hills and flats on the 'Trevenna' on-farm emissions site. The derived apparent electrical conductivity ($eC_a$) maps were used to stratify the 'Trevenna' landscape into basic soil zones on the basis that spatial variability in $eC_a$ was a surrogate indicator of soil textural differences (Corwin and Lesch 2005). Soil samples to a depth of 100 mm were taken at seven marked sites varying in $eC_a$ (see Figure 1). All soil samples were analysed for $pH_{(Ca)}$, organic carbon, phosphorus, sulphur and exchangeable cations. Additional soil samples across all the paddocks were taken at the beginning of the demonstration and were air-dried and stored for future analysis. Fertiliser was applied to the flats during May 2010 at the rate of 20kg/ha of phosphorus and 25 kg/ha of sulphur, 70 kg/ha of nitrogen and 5 kg/ha of white clover seed. Fertiliser was not applied to the flats in 2011.

Botanical composition, using the Botanal technique (Tothill *et al.* 1978) and herbage mass were assessed each season in pre- located sites. In addition pasture samples investigating quantity and quality were taken at entry and exit of sheep from each paddock using the median quadrat technique as outlined in the appendix of the PROGRAZE manual (NSW Department of Primary Industries 2007). Scans of pasture quadrats were taken before the quadrat was cut to determine green biomass using a Crop Circle (Holland Scientific equipment model ACS210). The image analysis data from the Crop Circle scans will be correlated with the actual green biomass to assist in calibrating the Crop Circle scans. Each paddock is also scanned along transects either north/south or east/west using Crop Circle equipment attached to a quad bike.

Water holding capacity measurements and $N_2O$ were also measured during the trial. A soil density calibration to provide a measure of plant available water (PAW) capacity for the hills and the flats will be undertaken and the data (bulk density, saturated water capacity (mm/mm), drained upper limit (mm/mm) @ 1 bar pressure, lower limit (mm/mm) @ 15 bar pressure, clay and sand percentages) will be used as inputs into the whole-farm decision support systems.

Selection of appropriate long-term stocking densities

Stocking density (DSE/ha) was determined using PRO Plus™ (McPhee *et al.* 2000), a whole-farm fodder budgeting decision support tool. Prior to commencement: the planning period, the area (ha) of each paddock, the estimated pasture growth rates (kg DM/ha/day) and intake (kg DM/ha) for each month and pasture biomass (kg DM/ha) at the beginning of the planning period, stock numbers and anticipated movement of stock between paddocks were entered into PRO Plus. Intake of supplementary feed (300g of grain and 300g of hay) and fodder quality were taken into consideration from September to mid-October. A fodder budget was calculated and used to modify stock numbers so that the livestock demand on pasture availability in early spring was met. The DSE/ha for individual paddocks on the two different landscapes and the overall DSE/ha for the hills and flats are reported.

Animal measurement and allocation

Three hundred and nine Merino ewes from the UNE Merino research flock were group-mated to four Border Leicester rams over 38 days at a ratio of ~1 ram to 77 ewes. All ewes were pregnancy tested 75 days post-joining using ultrasound, weighed and condition scored by palpitation. From these, 168 ewes carrying single lambs were selected for the trial (starting LW = 40.91kg± 4.00kg) and allocated to experimental groups; 48 to graze on the hills split into three flocks (n=16 per plot) grazing across three paddocks to create a blocking effect across the hills, and 96 to graze on the flats split into three flocks (n=32 per plot) grazing across three paddocks, again to create a blocking effect across the flats, and 24 ewes were kept as replacements. The allocation of ewes to flocks used stratified randomisation based on liveweight. Ewes were moved to their initial allocated paddocks eight days prior to the commencement of lambing on September 10 2010. Staple and tensile strength and fibre diameter samples were taken at shearing. Four ewes on the hills and four ewes on the flats had a GPS tracking device attached so that future research on the movement of ewes and lambs can be evaluated.

Experimental design

The experimental design is based on the plant soil and topographical features of the site; two landscapes (hills and flats) where each landscape is divided into three land classes (A, B, and C) each with three paddocks within each land class. In total 18 paddocks: nine on the hills and nine on the flats. Three flocks allocated to each of the landscapes with a rotation across the three land classes i.e. each flock rotationally grazes three allocated paddocks and hence rotationally grazes each land class (A, B, and C). The experimental design is not replicated within landscape, but the paddock subdivisions across the land classes are used as blocking effects to account for the variation across the landscapes. Replication of the experiment will occur across two years. Class and paddock were randomised before allocating flocks. Genstat version 13 (2010) was used to tabulate means and standard deviations and a two-way analysis of variance was performed to access differences between flocks.

### Demonstrations

Field days, visits to the site, and exposure of Trevenna at conferences have been collected. Evaluation forms at the field days were used to determine the success.

## Results

## Number of Field days, Advisor and Farmer Forums and evaluation from participants.

## March 2011 field day

A very successful field day was held at ‘Trevenna’, UNE, Armidale on the 29th March to showcase the demonstration trial and early results on reducing methane in sheep production systems. Over 70 producers, advisors and agency staff attended the field day, which highlighted the collaborative work between NSW DPI and UNE investigating this important and topical issue. NSW DPI extension and research staff helped deliverer, and coordinate, the event.

### Results from the evaluation of the field day

**Summary of Evaluation survey**

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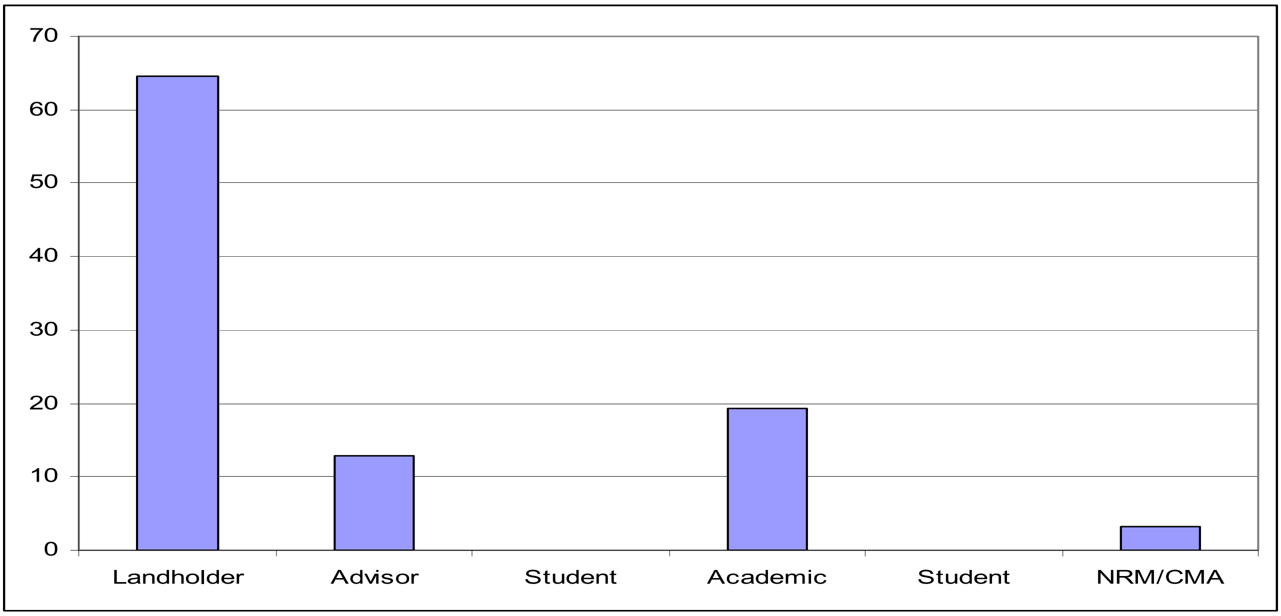
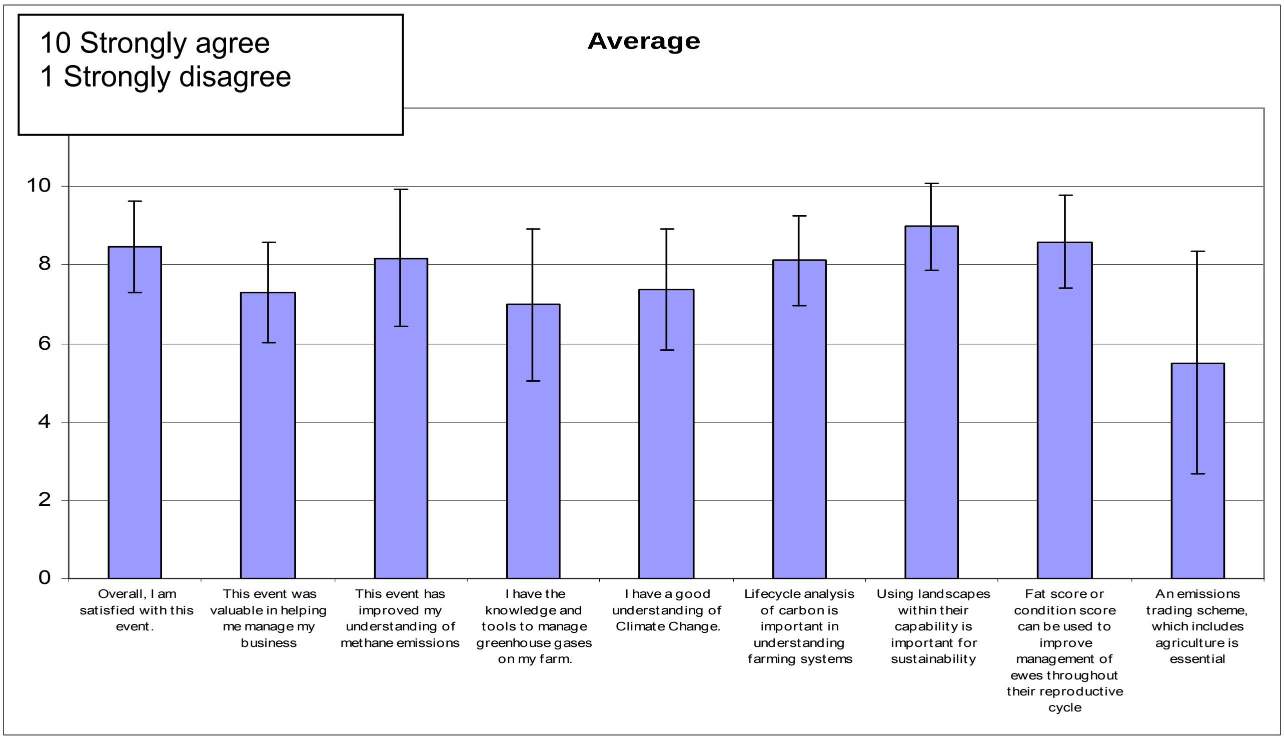
71 registrations
28 completed surveys handed in




Distribution of participants across various sectors




Response to questionnaire where 10 is strongly agree and 1 is strongly disagree

**How confident are you as a result of today that you can change your Methane emissions thru different mgt techniques** 7.36/10

65% were landholders: average landholding was 1,358 ha; 5,855 cattle and 51,780 sheep.

74% were confident as a result of the day to change their methane emissions through different management techniques.

95% said they could improve production efficiency/reduce emissions intensity on their farm.

5% said that they have already reduced paddock sizes to allow rotational grazing and that 50% of their property had some tree cover.

Producers indicated that they would consider the following for improving production efficiency/reduce emissions intensity on their farm were:

- Install and improve pastures
- Manage pasture quality
- Adapting pasture composition to lower methane output e.g. clover %
- Improve my pastures
- More pasture improvement, looking at feed supplements
- Higher intensity grazing systems
- Further improve pastures
- Better growth through better grazing management (rotations) … on breeder fertility
- Improve pastures
- Knowledge of the animal and pasture performance
- Develop a whole farm mgt programme to be profitable and not increase carbon footprint

- Use productive areas more efficiently

5% said no

- Have already reduced paddock sizes to allow rotational grazing 50% of property is tree cover

<u>General Feedback</u>

**What additional GHG info would you like to see developed/delivered?**

- C sequestration, thru advanced grazing and fertility
- Lots but not necessarily for field days!
- N2O
- Minimisation
- Nitrous Oxide
- Very important to acknowledge awareness of C cycling in the landscape and all results matched with the measure of C input to the livestock system
- Nitrous oxide emissions and their effects
- Need better cost effective measurements. Also economics of managing emissions and/or trading carbon
- Identify the genetic component. The full carbon budget
- More information on Nitrous oxide
- Affect of true native pastures and scrubland on emissions. Affect of using sheep coats on emissions
- Good gadget demonstrations
- Lifecycle analyses, how we can run both sheep and cattle and reduce emissions, methane from native pastures
- Government made aware of the value of trees on farms by regeneration rather than clearing and replanting
- Well organise, look forward to next day

## April 2012 field day

A supplementary report will be sent on the evaluation of this field day after the event has occurred on 3rd April 2012.

## Summary of the success of engaging with regional/farmer group participation

Since the project started up students from universities and schools, lecturers and teachers, research scientists and producers have visited the Trevenna site. The following Table highlights the number of participants that have either heard about the site or visited the site (up to 1st March 2012).

| Activity | When | Who | No of participants (visited site) |
|---|---|---|---|
| Brief overview of the project to Southern New England Landcare Committee, Uralla | 13 May 2010 | CE | 22 |
| Guest speakers at Lower Apsley Landcare group – Carbon field day | 21 June 2010 | MMP and CE | 65 |
| Introduction to the site and overview to I &I NSW executives | 9 July 2010 | MMP and CE | 10 (10) |
| Brief overview to Beef CRC BPP Guyra group | 23 August 2010 | CE | 19 |
| UNE students | August | DS | 30 (30) |
| Introduction to the site and overview to I &I NSW executives and staff | 27 August 2010 | MMP | 10 (10) |
| Brief overview of the project to Soil fertility field day, UNE | 7 October 2010 | CE | 33 (33) |
| Industry and Investment Livestock Officers | 20 October 2010 | JM | 4 (4) |
| Sheep CRC Annual Conference – Adelaide<br>“Managing sheep methane emissions by nutrition and flock management" | 21 October 2010 | RH | 350 |
| Guest speakers at Soil Carbon Day Ben Lomond Landcare group | 4 November 2010 | CE | 28 |
| Producer Advisory Group meeting | 10 November 2010 | JM, MMP CE | 8 (8) |
| Agricultural Societies Council, Youth group of NSW | 14 November 2010 | RH | 13 (13) |
| Introduction to site and overview PICSE teacher Professional Development Day | 25 November 2010 | RH | 30 (30) |
| Industry and Investment Beef and Sheep Conference, Tamworth Presentation | 30 November 2010 | CE | 68 |
| MLA - RELP group visited site | 15 December 2010 | MMP, JM | 2 (2) |
| PICSE students | 24 January 2011 | CE | 2 (2) |

| | | | |
|---|---|---|---|
| Industry and Investment Pasture DAs update internal meeting | 16 February 2011 | RH | 30 |
| SW-B Sheep Husbandry students | 3 March 2011 | MMP, JM | 32 (32) |
| National Sheep Nucleus Flock | 9 March 2011 | JM | 31 (31) |
| S W-B Sheep Husbandry Students | 10 March 2011 | JM | 33 (33) |
| MLA/DAFF meeting Brisbane - poster | 4 March 2011 | RH, MMP, CE | 30 |
| Landcare Adventure Guyra | 18 March 2011 | RH | 120 |
| UNE Students to see the FTIR | March 2011 | RH | 12 (12) |
| John Dillion fellows | 18 March 2011 | CE | 4 (4) |
| Trevenna Field day | 29 March 2011 | All | 71 (71) |
| CRC Precision Ag group | 31 March 2011 | JM | 15 (15) |
| PIIC symposia | 3 May 2011 | RH | 60 |
| Tenterfield Producers Bus tour | 11 May 2011 | CE JM | 22 (22) |
| Climate 11 Symposium Wagga | 22-23 June 2011 | CE | 110 |
| CC forum – BRG Inverell | 18-19 May 2011 | KLW | 130-160 |
| Soils North Coast Advisory Committee meeting, Grafton | 14 July 2011 | CE | 13 |
| Animal 315/415 students | 29 July 2011 | NB/Cedric | 35 (35) |
| Grassland Society of NSW Annual Conference | 27 – 28 July 2011 | CE | 150 |
| UNE students ANUT 321 prac | 29 August 2011 | RH and NB | 24 (24) |

| | | | |
|---|---|---|---|
| UNE presentation | 28 September 2011 | MMc | 4 |
| Grassland Society of NSW and DPI field day @ Glen Innes | 11 October 2011 | JM | 75 |
| Honours students presentation | 17 October 2011 | RP | 50 |

| | | | |
|---|---|---|---|
| A Cosby - Science teachers | Nov 2011 | RH | 20 (20) |
| Armidale Prograze group | 25 November 2011 | CE, JM | 25 (25) |
| Australasian Pacific Extension Network pre Conference tour | 28 November 2011 | RH, MMP, JM, CE | 40 (40) |
| Mair Morgan Research Consultant ADAS | 16 December 2011 | NB | |
| PICSE Science teachers | 6 February 2011 | RH | 15 (15) |
| Chinese delegation from Jilin Academy of Agricultural Sciences | 15 February 2011 | RH | 6 (6)? |
| Rural Women's group | 17 February 2012 | RH/CE | 17 (10) |
| Wool 412 students | 21 February 2012 | NB | 20 (20) |
| PIARN Master Class - Canberra | 22 February 2011 | CE | 30 |
| Wool 412 students | 28 February 2011 | NB | 20 (20) |
| National Woolgrowers Association of South Africa | 28 February 2011 | RH | 4 (4) |
| **Overall Total May 2010 – February 2012** | | | **1972 (496)** |

| |
|---|
| 48 events Trevenna was mentioned, 29 events held on site May 2010 – February 2012 |

## What's planned March – April 2012

| Activity | When | Who | No of participants (visited site) |
|---|---|---|---|
| ANPR 211 students | 1 March | | 40 (40) |
| Ag teachers Professional development day | 2 March | RH | 350 (230) |
| ANPR 211 students | 8 March | | 40 (40) |
| Muscle scanning plus wool 412 students | 6 March | | 20 (20) |
| Nuffield Scholars (UK) | 17 March 2011 | CE | 70 (70) |
| Landcare Adventure Inverell | 26 March | JM | Est. 120 |
| Trevenna field day | 3 April | ALL | Est. 60-70 (60 – 70) |
| | | | |
| **ESTIMATED Total March – April 2012** | | | **potential 420 (300)** |
| **OVER May 2010 – April 2012**<br>**56 events that mentioned Trevenna and 35 of those events held at the Trevenna site** | | | **potential 2392 (796)** |

CE – Clare Edwards; MMP – Malcolm McPhee; JM – Jim Meckiff; RH – Roger Hegarty; KLW – Kate Lorimer-Ward; NB - Neil Ballie

Tables 1 to 9 provide detail of the paddocks sizes, stock numbers and rotational movement dates between paddocks, observed pasture biomass, soil sample analysis, pasture quality at specified dates for green and dead pasture biomass, and quality of supplementary feed.

Table 1. Area of paddocks for low and high productivity landscapes.

| Low productivity | | High productivity | |
|---|---|---|---|
| **Paddock** | **Area (ha)** | **Paddock** | **Area (ha)** |
| HA1 | 1.8 | FA1 | 2.2 |
| HA2 | 1.8 | FA2 | 2.1 |
| HA3 | 2.0 | FA3 | 2.1 |
| HB1 | 1.8 | FB1 | 2.1 |
| HB2 | 1.9 | FB2 | 2.1 |
| HB3 | 2 | FB3 | 2.2 |
| HC1 | 1.8 | FC1 | 2.1 |
| HC2 | 1.9 | FC2 | 2.0 |
| HC3 | 2.0 | FC3 | 1.9 |
| Total area | 17.0 | Total area | 18.8 |

Table 2. Area of paddocks used for winter grazing and predominant pasture species.

| Paddock | Area (ha) | Species |
|---|---|---|
| D1 | 5 | C3 |
| D2 | 2.5 | C3 |
| S1 | 2.1 | C3 |
| McMillian | 6.1 | Fescue/Paspalum |
| Millgate | 20 | Fescue/Phalaris[1] |

1. Estimate of 1,300 kg DM/ha of improved pasture

Table 3. Ewe and lamb stock numbers for low and high productivity landscapes in year1.

| | Low productivity | | High productivity | |
|---|---|---|---|---|
| Month | Ewe | Lamb | Ewe | Lamb |
| Jan | 48 | 45 | 96 | 94 |
| Feb | 48 | 45 | 96 | 94 |
| Mar | 48 | 45 | 96 | 94 |
| Apr | 48 | 44 | 96 | 93 |
| May | 48 | - | 96 | - |
| Jun | 48 | - | 96 | - |
| Jul | 48 | - | 96 | - |
| Aug | 48 | - | 96 | - |
| Sep | 48 | 45 | 96 | 94 |
| Oct | 48 | 45 | 96 | 94 |
| Nov | 48 | 45 | 96 | 94 |
| Dec | 48 | 45 | 96 | 94 |

Table 4. Movement dates for flocks between paddocks across the low and high productivity landscapes

| **Date** | | **Flock** | **Paddock** | **Flock** | **Paddock** |
|---|---|---|---|---|---|
| **In** | **Out** | **Low** | **Low** | **High** | **High** |
| 1 Sep | 9 Oct | 1,2,3 | HB3, HC3, HA2 | 4,5,6 | FC3, FB3, FA3 |
| 10 Oct | 31 Oct | 1,2,3 | HC2, HA1, HB1 | 4,5,6 | FA1, FC2, FB1 |
| 1 Nov | 30 Nov | 1,2,3 | HA3, HB2, HC1 | 4,5,6 | FB2, FA2, FC1 |
| 1 Dec | 31 Dec | 1,2,3 | HB3, HC3, HA2 | 4,5,6 | FC3, FB3, FA3 |
| 1 Jan | 31 Jan | 1,2,3 | HC2, HA1, HB1 | 4,5,6 | FA1, FC2, FB1 |
| 1 Feb | 29 Feb | 1,2,3 | HA3, HB2, HC1 | 4,5,6 | FB2, FA2, FC1 |
| 1 Mar | 31 Mar | 1,2,3 | HB3, HC3, HA2 | 4,5,6 | FC3, FB3, FA3 |
| ***Winter grazing*** | | | | | |
| 1 Apr | 15 Apr | All flocks | D1 | | |
| 16 Apr | 27 Apr | All flocks | D2 | | |
| 28 Apr | 5 May | All flocks | D1 | | |
| 6 May | 8 May | All flocks | S1 | | |
| 9 May | 29 May | All flocks | McMillian | | |
| 30 May | 7 Aug | All flocks | Millgate | | |
| 8 Aug | 31 Aug | All flocks | D1 | | |

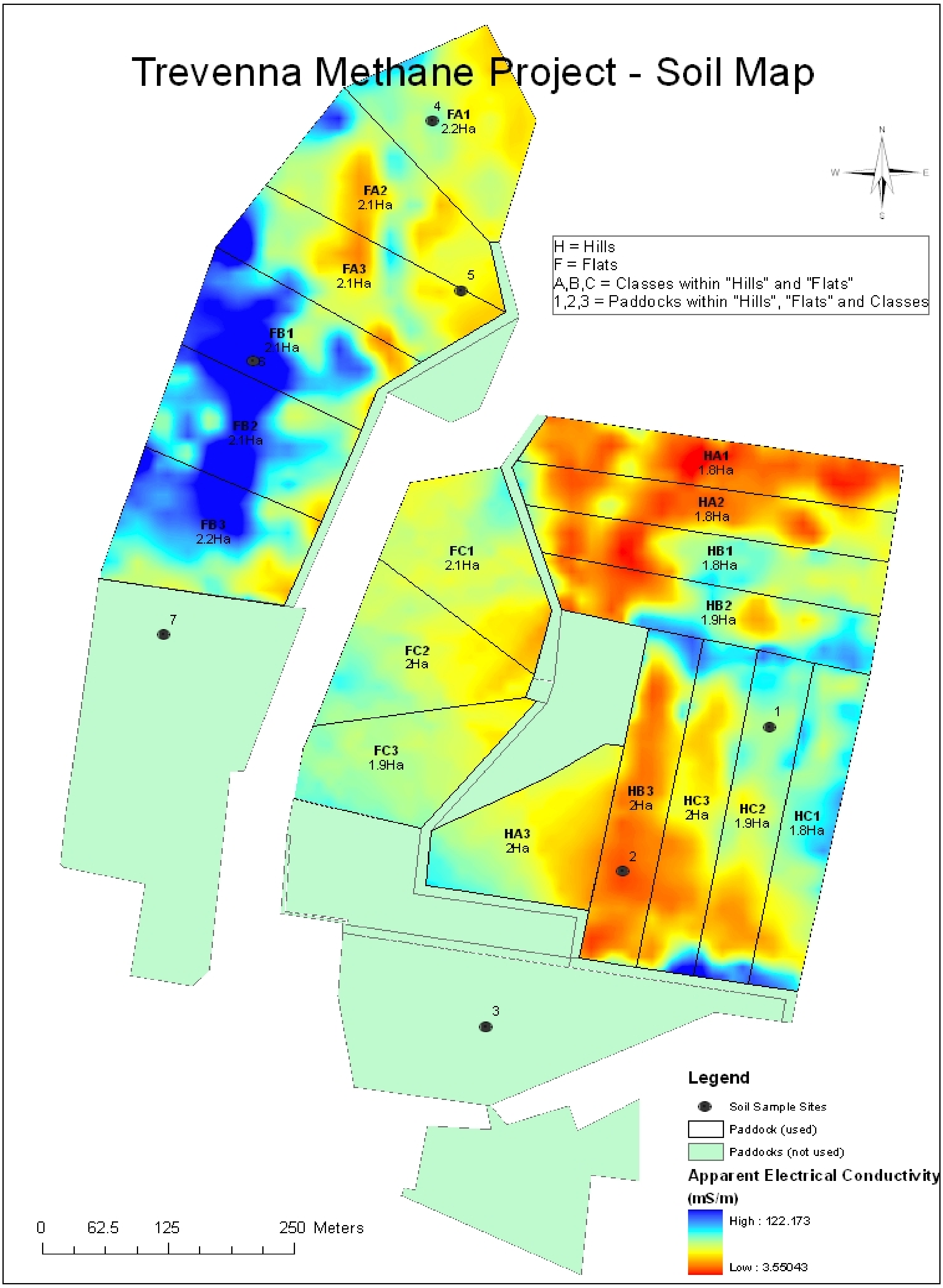



Figure 1. Paddock layout and size of paddocks for the low (hills (H)) and high (flats (F)) productivity landscapes and their classes (A,B, and C) within the landscapes at the Trevenna on-farm methane emissions demonstration site, Armidale, the soil GPS satellite classification and sample sites

Table 5. Observed pasture for total herbage mass (THM) green herbage mass (GHM), dead herbage mass (DHM), and ratio of green to dead (RGT) across landscapes at pasture assessment dates in year 1 from September to March; mean (±SD).

| | Low productivity | | | | High productivity | | | |
|---|---|---|---|---|---|---|---|---|
| **Date** | **THM** | **GHM** | **DHM** | **RGT** | **THM** | **GHM** | **DHM** | **RGT** |
| 8.09.2010 | 4911 | 184 | 4727 | 0.04 | 2988 | 1359 | 1629 | 0.49 |
| | ( 1353 ) | ( 192 ) | ( 1407 ) | ( 0.05 ) | ( 801 ) | ( 814 ) | ( 1097 ) | ( 0.28 ) |
| 18.10.2010 | 3765 | 757 | 3088 | 0.2 | 2274 | 1981 | 293 | 0.84 |
| | ( 1453 ) | ( 972 ) | ( 1627 ) | ( 0.28 ) | ( 940 ) | ( 1098 ) | ( 511 ) | ( 0.26 ) |
| 9.11.2010 | 5382 | 2936 | 2446 | 0.58 | 7330 | 6617 | 713 | 0.9 |
| | ( 1444 ) | ( 1393 ) | ( 1899 ) | ( 0.29 ) | ( 3039 ) | ( 2910 ) | ( 790 ) | ( 0.09 ) |
| 7.12.2010 | 6033 | 1193 | 4841 | 0.2 | 8793 | 3690 | 5103 | 0.45 |
| | ( 1343 ) | ( 1080 ) | ( 1580 ) | ( 0.17 ) | ( 3125 ) | ( 3124 ) | ( 4208 ) | ( 0.36 ) |
| 1.02.2011 | 5077 | 1160 | 3917 | 0.23 | 6881 | 1271 | 5610 | 0.19 |
| | ( 1601 ) | ( 810 ) | ( 1443 ) | ( 0.13 ) | ( 1395 ) | ( 691 ) | ( 1380 ) | ( 0.11 ) |
| 9.03.2011 | 5147 | 1526 | 3621 | 0.3 | 6362 | 2017 | 4345 | 0.29 |
| | ( 1413 ) | ( 978 ) | ( 1390 ) | ( 0.16 ) | ( 1983 ) | ( 1533 ) | ( 1083 ) | ( 0.17 ) |

Table 6. Results from soil sample analysis taken across seven sites at the Trevenna on-farm methane emissions demonstration site across 2 years. Sampling sites are identified on the site map provided in Figure 1.

| **Soil parameter** | **Sampling site** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7*** |
| ***May 2010*** | | | | | | | |
| pH (1:5 CaCl2) | 5.4 | 5.2 | 5.6 | 4.7 | 4.9 | 4.8 | 5.1 |
| Organic Carbon (%) | 3.8 | 3.7 | 2.6 | 1.3 | 2.0 | 2.9 | 1.2 |
| SulphateSulphur (KCl40) (mg/kg) | 6.2 | 5.5 | 2.8 | 5.1 | 4.1 | 7.8 | 2.6 |
| Phosphorus (Colwell) (mg/kg) | 85 | 51 | 100 | 71 | 69 | 91 | 130 |
| Phosphorus Buffer Index | 190 | 150 | 200 | 61 | 53 | 140 | 35 |
| Cation Exch. Cap. (CEC) (meq/100g) | 29.4 | 13.7 | 41.0 | 4.61 | 8.56 | 11.6 | 3.11 |
| ***May 2011*** | | | | | | | |
| pH (1:5 CaCl2) | 5.6 | 5.1 | 6.3 | 4.9 | 5.1 | 4.9 | 5.1 |
| Organic Carbon (%) | 4.6 | 4.3 | 4.1 | 1.5 | 2.1 | 2.5 | 2.1 |
| SulphateSulphur (KCl40) (mg/kg) | 7.3 | 5.5 | 4.8 | 6.3 | 4.8 | 7.2 | 6.2 |
| Phosphorus (Colwell) (mg/kg) | 140 | 51 | 87 | 86 | 73 | 60 | 55 |
| Phosphorus Buffer Index | 220 | 170 | 160 | 68 | 70 | 58 | 88 |
| Cation Exch. Cap. (CEC) (meq/100g) | 33.6 | 13.0 | 57.7 | 4.3 | 9.2 | 8.1 | 6.9 |

*Site changed

Table 7. Pasture quality of green biomass in year 1 across paddocks at selected dates. Feed tests from FeedQuality service, NSW DPI, Wagga Wagga

| Date | Pdk | NDF (%) | CP (%) | DMD (%) | DOMD (%) | ME (MJ/kg DM) |
|---|---|---|---|---|---|---|
| 18/10/10 | FA1 | 51 | 16.7 | 69 | 65 | 10.2 |
| 18/10/10 | FA3 | 56 | 13.8 | 66 | 63 | 9.7 |
| 18/10/10 | FB1 | 49 | 11.9 | 77 | 72 | 11.6 |
| 18/10/10 | FB3 | - | - | - | - | - |
| 18/10/10 | FC2 | 53 | 18.7 | 65 | 62 | 9.5 |
| 18/10/10 | HA1 | 55 | 12.1 | 63 | 60 | 9.2 |
| 18/10/10 | HA2 | 49 | 16.4 | 75 | 71 | 11.4 |
| 18/10/10 | HB1 | 54 | 11.1 | 67 | 63 | 9.9 |
| 18/10/10 | HB3 | 52 | 16.8 | 65 | 62 | 9.6 |
| 18/10/10 | HC2 | 49 | 16.6 | 59 | 57 | 8.5 |
| 18/10/10 | HC3 | 55 | 13 | 63 | 60 | 9.3 |
| 1/02/11 | FA2 | 55 | 13.8 | 58 | 56 | 8.3 |
| 1/02/11 | FB1 | 61 | 12.8 | 53 | 52 | 7.5 |
| 1/02/11 | FC1 | 57 | 16.4 | 62 | 59 | 9 |
| 1/02/11 | FC2 | 64 | 11.6 | 58 | 56 | 8.3 |
| 1/02/11 | HA1 | 62 | 8 | 52 | 51 | 7.4 |
| 1/02/11 | HB1 | 61 | 5.8 | 52 | 51 | 7.3 |
| 1/02/11 | HC1 | 53 | 8.1 | 59 | 57 | 8.5 |
| 1/02/11 | HC2 | 60 | 3.6 | 55 | 53 | 7.8 |
| 9/03/11 | FA2 | 59 | 19.2 | 59 | 57 | 8.5 |
| 9/03/11 | FA3 | 59 | 12.9 | 56 | 55 | 8.1 |
| 9/03/11 | FB2 | 56 | 19.1 | 60 | 58 | 8.7 |
| 9/03/11 | FB3 | 54 | 15.6 | 61 | 59 | 8.9 |
| 9/03/11 | FC1 | 62 | 15.6 | 56 | 54 | 8 |
| 9/03/11 | FC3 | 53 | 16.1 | 62 | 59 | 9 |
| 9/03/11 | HA3 | 65 | 7.8 | 56 | 54 | 8 |
| 9/03/11 | HB2 | 64 | 7.1 | 53 | 51 | 7.4 |
| 9/03/11 | HC1 | 66 | 6 | 55 | 53 | 7.8 |

Table 8. Pasture quality of dead biomass in year 1 across paddocks at selected dates

| Date | Pdk | NDF (%) | CP (%) | DMD (%) | DOMD (%) | ME (MJ/kg DM) |
|---|---|---|---|---|---|---|
| 18/10/10 | FA1 | - | - | - | - | - |
| 18/10/10 | FA3 | 64 | 8.1 | 59 | 57 | 8.5 |
| 18/10/10 | FB1 | 73 | 6.2 | 39 | 39 | 4.9 |
| 18/10/10 | FB3 | 59 | 9.5 | 57 | 55 | 8.3 |
| 18/10/10 | FC2 | 73 | 8.3 | 43 | 43 | 5.7 |
| 18/10/10 | HA1 | 74 | 5.9 | 40 | 41 | 5.3 |
| 18/10/10 | HA2 | - | - | - | - | - |
| 18/10/10 | HB1 | 67 | 7.9 | 44 | 44 | 6 |
| 18/10/10 | HB3 | 68 | 8.9 | 42 | 42 | 5.5 |
| 18/10/10 | HC2 | 76 | 6.2 | 39 | 38 | 4.3 |
| 18/10/10 | HC3 | - | - | - | - | - |
| 1/02/11 | FA2 | 73 | 5 | 41 | 42 | 5.5 |
| 1/02/11 | FB1 | 78 | 7 | 41 | 41 | 5.4 |
| 1/02/11 | FC1 | 69 | 8.9 | 46 | 45 | 6.2 |
| 1/02/11 | FC2 | 68 | 8.8 | 44 | 44 | 6 |
| 1/02/11 | HA1 | 71 | 3.9 | 39 | 40 | 5.1 |
| 1/02/11 | HB1 | 69 | 4.8 | 44 | 44 | 5.9 |
| 1/02/11 | HC1 | 52 | 6.1 | 51 | 50 | 7.1 |
| 1/02/11 | HC2 | 63 | 4.2 | 45 | 45 | 6.1 |
| 9/03/11 | FA2 | 71 | 12.5 | 47 | 46 | 6.4 |
| 9/03/11 | FA3 | 68 | 9.8 | 50 | 49 | 7 |
| 9/03/11 | FB2 | 71 | 12.5 | 45 | 45 | 6.2 |
| 9/03/11 | FB3 | 58 | 13.5 | 54 | 52 | 7.6 |
| 9/03/11 | FC1 | 68 | 11.5 | 42 | 43 | 5.7 |
| 9/03/11 | FC3 | 70 | 10.8 | 45 | 45 | 6 |
| 9/03/11 | HA3 | 67 | 7.3 | 46 | 46 | 6.3 |
| 9/03/11 | HB2 | 70 | 5.9 | 46 | 46 | 6.4 |
| 9/03/11 | HC1 | 69 | 5.4 | 47 | 46 | 6.4 |

Table 9. Supplementary feed quality of lucerne hay (LH), faba beans (FB), and lupins (LU) fed to ewes in year 1 and year2. Results from Feed Quality Service, NSW DPI, Wagga Wagga.

| Date | Feed | DM (%) | NDF (%) | ADF (%) | CP (%) | IOA (%) | OA (%) | DMD (%) | DOMD (%) | ME (MJ/ kg DM) | CF (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Year 1*** | | | | | | | | | | | |
| 05-Aug-10 | LH | 86.1 | 47 | 32 | 21.1 | 9 | 91 | 62 | 59 | 9 | - |
| 05-Aug-10 | FB | 92.4 | 14 | 7 | 25.3 | 4 | 96 | 85 | 84 | 12.9 | 1.4 |
| 07-Sep-10 | LH | 87.7 | 44 | 31 | 22.2 | 10 | 90 | 67 | 64 | 10 | - |
| ***Year 2*** | | | | | | | | | | | |
| 23-Aug-11 | LU | 92.0 | 38 | 18 | 37 | 4 | 96 | 82 | 81 | 14.6 | 9.3 |

Equation 1 was used to estimate green biomass (GHM) using the NDVI index and the ratios reported in Table #. were used to calculate the amount of total herbage biomass (Tables # to #).

$$GHM = 37.73xEXP\ (5.86xNDVI)\ (R^2=0.43) \quad \text{(Equ. 1)}$$

Tables 10 to 25 provide details of pasture biomass (total, green, and dead) at sampling dates based on botanical composition sampling dates for each paddock within a sample class.

Table 10. Total herbage biomass (THM) and green herbage biomass (GHM) based on Normalized Difference Vegetation Index (**NDVI**) conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 29.08.2010

| | **B.Comp (%)** | **Pasture Biomass (kg DM/ha)** | | | | | |
|---|---|---|---|---|---|---|---|
| | **Land class** | **HA1** | | **HA2** | | **HA3** | |
| **Species** | **A** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 59 | 7876 | 315 | 7434 | 297 | 7567 | 303 |
| C4 Native | 37 | 4940 | 198 | 4662 | 186 | 4745 | 190 |
| P.Rye | 2 | 267 | 11 | 252 | 10 | 256 | 10 |
| Other* | 2 | 267 | 11 | 252 | 10 | 256 | 10 |
| Total | 100 | 13350 | 534 | 12600 | 504 | 12825 | 513 |
| | **Land class** | **HB1** | | **HB2** | | **HB3** | |
| **Species** | **B** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 61 | 8723 | 349 | 8235 | 329 | 6481 | 259 |
| C4 Native | 21 | 3003 | 120 | 2835 | 113 | 2231 | 89 |
| Other | 18 | 2574 | 103 | 2430 | 97 | 1912 | 76 |
| Total | 100 | 14300 | 572 | 13500 | 540 | 10625 | 425 |
| | **Land class** | **HC1** | | **HC2** | | **HC3** | |
| **Species** | **C** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 18 | 3938 | 158 | 2578 | 103 | 2925 | 117 |
| C4 Native | 55 | 12031 | 481 | 7879 | 315 | 8938 | 358 |
| Phalaris | 2 | 438 | 18 | 286 | 11 | 325 | 13 |
| Other | 24 | 5250 | 210 | 3438 | 138 | 3900 | 156 |
| Annual | 1 | 219 | 9 | 143 | 6 | 162 | 6 |
| Total | 100 | 21875 | 875 | 14325 | 573 | 16250 | 650 |

* Annual Ryegrass

Table 11. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 29.08.2010

| | **B.Comp (%)** | **Pasture Biomass (kg DM/ha)** | | | | | |
|---|---|---|---|---|---|---|---|
| | **Land class** | **FA1** | | **FA2** | | **FA3** | |
| **Species** | **A** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 2 | 73 | 36 | 83 | 41 | 97 | 47 |
| C4 Native | 1 | 37 | 18 | 42 | 20 | 48 | 24 |
| P Rye | 93 | 3401 | 1667 | 3878 | 1900 | 4496 | 2203 |
| White Clover | 3 | 110 | 54 | 125 | 61 | 145 | 71 |
| Other | 1 | 37 | 18 | 42 | 20 | 48 | 24 |
| | 100 | 3657 | 1792 | 4169 | 2043 | 4835 | 2369 |
| | **Land class** | **FB1** | | **FB2** | | **FB3** | |
| **Species** | **B** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 1 | 49 | 24 | 29 | 14 | 33 | 16 |
| C4 Native | 11 | 537 | 263 | 323 | 158 | 359 | 176 |
| P Rye | 37 | 1808 | 886 | 1086 | 532 | 1208 | 592 |
| White Clover | 1 | 49 | 24 | 29 | 14 | 33 | 16 |
| Other[1] | 36 | 1759 | 862 | 1056 | 518 | 1176 | 576 |
| Annual Grass | 14 | 684 | 335 | 411 | 201 | 457 | 224 |
| Total | 100 | 4886 | 2394 | 2935 | 1438 | 3265 | 1600 |
| | **Land class** | **FC1** | | **FC2** | | **FC3** | |
| **Species** | **C** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 1 | 58 | 29 | 57 | 28 | 57 | 28 |
| C4 Native | 6 | 349 | 171 | 342 | 167 | 344 | 168 |
| Phalaris | 14 | 815 | 399 | 797 | 391 | 802 | 393 |
| P Rye | 59 | 3435 | 1683 | 3361 | 1647 | 3380 | 1656 |
| Tall Fescue | 7 | 408 | 200 | 399 | 195 | 401 | 196 |
| Paspalum | 1 | 58 | 29 | 57 | 28 | 57 | 28 |
| Brome | 3 | 175 | 86 | 171 | 84 | 172 | 84 |
| Other | 9 | 524 | 257 | 513 | 251 | 516 | 253 |
| Total | 100 | 5822 | 2853 | 5696 | 2791 | 5729 | 2807 |

[1.] Broad leaf plants

Table 12. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 18.10.2010

| | B.Comp (%) | Pasture Biomass (kg DM/ha) | | | | | |
|---|---|---|---|---|---|---|---|
| | Land class | HA1 | | HA2 | | HA3 | |
| Species | A | THM | GHM | THM | GHM | THM | GHM |
| C3 Native | 59 | 5694 | 315 | 2997 | 297 | 5006 | 303 |
| C4 Native | 37 | 3570 | 198 | 1880 | 186 | 3139 | 190 |
| P Rye | 2 | 193 | 11 | 102 | 10 | 170 | 10 |
| Other | 2 | 193 | 11 | 102 | 10 | 170 | 10 |
| Total | 100 | 9650 | 534 | 5080 | 504 | 8485 | 513 |
| | Land class | HB1 | | HB2 | | HB3 | |
| Species | B | THM | GHM | THM | GHM | THM | GHM |
| C3 Native | 61 | 5212 | 349 | 5280 | 329 | 2544 | 259 |
| C4 Native | 21 | 1794 | 120 | 1818 | 113 | 876 | 89 |
| Other | 18 | 1538 | 103 | 1558 | 97 | 751 | 76 |
| Total | 100 | 8545 | 572 | 8655 | 540 | 4170 | 425 |
| | Land class | HC1 | | HC2 | | HC3 | |
| Species | C | THM | GHM | THM | GHM | THM | GHM |
| C3 Native | 18 | 2392 | 158 | 1789 | 103 | 1902 | 117 |
| C4 Native | 55 | 7310 | 481 | 5467 | 315 | 5811 | 358 |
| Phalaris | 2 | 266 | 18 | 199 | 11 | 211 | 13 |
| Other | 24 | 3190 | 210 | 2386 | 138 | 2536 | 156 |
| Annual Grass | 1 | 133 | 9 | 99 | 6 | 106 | 6 |
| Total | 100 | 13290 | 875 | 9940 | 573 | 10565 | 650 |

Table 13. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 18.10.2010

| | B.Comp (%) | Pasture Biomass (kg DM/ha) | | | | | |
|---|---|---|---|---|---|---|---|
| | Land class | FA1 | | FA2 | | FA3 | |
| Species | A | THM | GHM | THM | GHM | THM | GHM |
| C3 Native | 2 | 146 | 36 | 150 | 41 | 83 | 47 |
| C4 Native | 1 | 73 | 18 | 75 | 20 | 42 | 24 |
| P Rye | 93 | 6810 | 1667 | 6987 | 1900 | 3882 | 2203 |
| White Clover | 3 | 220 | 54 | 225 | 61 | 125 | 71 |
| Other | 1 | 73 | 18 | 75 | 20 | 42 | 24 |
| Total | 100 | 7323 | 1792 | 7513 | 2043 | 4174 | 2369 |
| | Land class | FB1 | | FB2 | | FB3 | |
| Species | B | THM | GHM | THM | GHM | THM | GHM |
| C3 Native | 1 | 63 | 24 | 47 | 14 | 23 | 16 |
| C4 Native | 11 | 695 | 263 | 512 | 158 | 248 | 176 |
| P Rye | 37 | 2339 | 886 | 1722 | 532 | 834 | 592 |
| White Clover | 1 | 63 | 24 | 47 | 14 | 23 | 16 |
| Other | 36 | 2276 | 862 | 1675 | 518 | 811 | 576 |
| Annual Grass | 14 | 885 | 335 | 652 | 201 | 316 | 224 |
| Total | 100 | 6321 | 2394 | 4654 | 1438 | 2254 | 1600 |
| | Land class | FC1 | | FC2 | | FC3 | |
| Species | C | THM | GHM | THM | GHM | THM | GHM |
| C3 Native | 1 | 79 | 29 | 70 | 28 | 49 | 28 |
| C4 Native | 6 | 474 | 171 | 420 | 167 | 295 | 168 |
| Phalaris | 14 | 1106 | 399 | 980 | 391 | 689 | 393 |
| P Rye | 59 | 4660 | 1683 | 4129 | 1647 | 2902 | 1656 |
| Tall Fescue | 7 | 553 | 200 | 490 | 195 | 344 | 196 |
| Paspalum | 1 | 79 | 29 | 70 | 28 | 49 | 28 |
| Brome | 3 | 237 | 86 | 210 | 84 | 148 | 84 |
| Other | 9 | 711 | 257 | 630 | 251 | 443 | 253 |
| Total | 100 | 7899 | 2853 | 6999 | 2791 | 4919 | 2807 |

Table 14. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 10.11.2010

| | B.Comp (%) | Pasture Biomass (kg DM/ha) | | | | | |
|---|---|---|---|---|---|---|---|
| | Land class | HA1 | | HA2 | | HA3 | |
| **Species** | **A** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 59 | 1433 | 315 | 1511 | 297 | 2969 | 303 |
| C4 Native | 37 | 899 | 198 | 947 | 186 | 1862 | 190 |
| P Rye | 2 | 49 | 11 | 51 | 10 | 101 | 10 |
| Other | 2 | 49 | 11 | 51 | 10 | 101 | 10 |
| Total | 100 | 2429 | 534 | 2560 | 504 | 5033 | 513 |
| | **Land class** | **HB1** | | **HB2** | | **HB3** | |
| **Species** | **B** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 61 | 1367 | 349 | 2083 | 329 | 1518 | 259 |
| C4 Native | 21 | 471 | 120 | 717 | 113 | 522 | 89 |
| Other | 18 | 403 | 103 | 615 | 97 | 448 | 76 |
| Total | 100 | 2241 | 572 | 3416 | 540 | 2488 | 425 |
| | **Land class** | **HC1** | | **HC2** | | **HC3** | |
| **Species** | **C** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 18 | 1096 | 158 | 736 | 103 | 767 | 117 |
| C4 Native | 55 | 3347 | 481 | 2247 | 315 | 2345 | 358 |
| Phalaris | 2 | 122 | 18 | 82 | 11 | 85 | 13 |
| Other | 24 | 1461 | 210 | 981 | 138 | 1023 | 156 |
| Annual Grass | 1 | 61 | 9 | 41 | 6 | 43 | 6 |
| Total | 100 | 6086 | 875 | 4086 | 573 | 4264 | 650 |

Table 15. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 10.11.2010

| | B.Comp (%) | Pasture Biomass (kg DM/ha) | | | | | |
|---|---|---|---|---|---|---|---|
| | Land class | FA1 | | FA2 | | FA3 | |
| **Species** | **A** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 2 | 97 | 36 | 126 | 41 | 141 | 47 |
| C4 Native | 1 | 49 | 18 | 63 | 20 | 70 | 24 |
| P Rye | 93 | 4517 | 1667 | 5867 | 1900 | 6551 | 2203 |
| White Clover | 3 | 146 | 54 | 189 | 61 | 211 | 71 |
| Other | 1 | 49 | 18 | 63 | 20 | 70 | 24 |
| Total | 100 | 4857 | 1792 | 6309 | 2043 | 7044 | 2369 |
| | **Land class** | **FB1** | | **FB2** | | **FB3** | |
| **Species** | **B** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 1 | 45 | 24 | 44 | 14 | 51 | 16 |
| C4 Native | 11 | 496 | 263 | 485 | 158 | 557 | 176 |
| P Rye | 37 | 1667 | 886 | 1632 | 532 | 1873 | 592 |
| White Clover | 1 | 45 | 24 | 44 | 14 | 51 | 16 |
| Other | 36 | 1622 | 862 | 1588 | 518 | 1823 | 576 |
| Annual Grass | 14 | 631 | 335 | 617 | 201 | 709 | 224 |
| Total | 100 | 4506 | 2394 | 4410 | 1438 | 5063 | 1600 |
| | **Land class** | **FC1** | | **FC2** | | **FC3** | |
| **Species** | **C** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 1 | 57 | 29 | 45 | 28 | 73 | 28 |
| C4 Native | 6 | 340 | 171 | 271 | 167 | 437 | 168 |
| Phalaris | 14 | 794 | 399 | 632 | 391 | 1019 | 393 |
| P Rye | 59 | 3348 | 1683 | 2664 | 1647 | 4294 | 1656 |
| Tall Fescue | 7 | 397 | 200 | 316 | 195 | 509 | 196 |
| Paspalum | 1 | 57 | 29 | 45 | 28 | 73 | 28 |
| Brome | 3 | 170 | 86 | 135 | 84 | 218 | 84 |
| Other | 9 | 511 | 257 | 406 | 251 | 655 | 253 |
| Total | 100 | 5674 | 2853 | 4516 | 2791 | 7278 | 2807 |

Table 16. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 08.12.2010

| | B.Comp (%) | Pasture Biomass (kg DM/ha) | | | | | |
|---|---|---|---|---|---|---|---|
| | Land class | HA1 | | HA2 | | HA3 | |
| Species | A | THM | GHM | THM | GHM | THM | GHM |
| C3 Native | 59 | 6449 | 315 | 6906 | 297 | 10593 | 303 |
| C4 Native | 37 | 4044 | 198 | 4331 | 186 | 6643 | 190 |
| P Rye | 2 | 219 | 11 | 234 | 10 | 359 | 10 |
| Other | 2 | 219 | 11 | 234 | 10 | 359 | 10 |
| Total | 100 | 10930 | 534 | 11705 | 504 | 17955 | 513 |
| | Land class | HB1 | | HB2 | | HB3 | |
| Species | B | THM | GHM | THM | GHM | THM | GHM |
| C3 Native | 61 | 5783 | 349 | 4740 | 329 | 7631 | 259 |
| C4 Native | 21 | 1991 | 120 | 1632 | 113 | 2627 | 89 |
| Other | 18 | 1706 | 103 | 1399 | 97 | 2252 | 76 |
| Total | 100 | 9480 | 572 | 7770 | 540 | 12510 | 425 |
| | Land class | HC1 | | HC2 | | HC3 | |
| Species | C | THM | GHM | THM | GHM | THM | GHM |
| C3 Native | 18 | 2640 | 158 | 3141 | 103 | 1464 | 117 |
| C4 Native | 55 | 8066 | 481 | 9598 | 315 | 4474 | 358 |
| Phalaris | 2 | 293 | 18 | 349 | 11 | 163 | 13 |
| Other | 24 | 3520 | 210 | 4188 | 138 | 1952 | 156 |
| Annual Grass | 1 | 147 | 9 | 174 | 6 | 81 | 6 |
| Total | 100 | 14665 | 875 | 17450 | 573 | 8135 | 650 |

Table 17. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.09.2010) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 08.12.2010

| | **B.Comp (%)** | **Pasture Biomass (kg DM/ha)** | | | | | |
|---|---|---|---|---|---|---|---|
| | **Land class** | **FA1** | | **FA2** | | **FA3** | |
| **Species** | **A** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 2 | 120 | 36 | 115 | 41 | 192 | 47 |
| C4 Native | 1 | 60 | 18 | 58 | 20 | 96 | 24 |
| P Rye | 93 | 5566 | 1667 | 5349 | 1900 | 8932 | 2203 |
| White Clover | 3 | 180 | 54 | 173 | 61 | 288 | 71 |
| Other | 1 | 60 | 18 | 58 | 20 | 96 | 24 |
| Total | 100 | 5984 | 1792 | 5751 | 2043 | 9604 | 2369 |
| | **Land class** | **FB1** | | **FB2** | | **FB3** | |
| **Species** | **B** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 1 | 70 | 24 | 46 | 14 | 89 | 16 |
| C4 Native | 11 | 771 | 263 | 510 | 158 | 979 | 176 |
| P Rye | 37 | 2595 | 886 | 1716 | 532 | 3292 | 592 |
| White Clover | 1 | 70 | 24 | 46 | 14 | 89 | 16 |
| Other | 36 | 2525 | 862 | 1670 | 518 | 3203 | 576 |
| Annual Grass | 14 | 982 | 335 | 649 | 201 | 1246 | 224 |
| Total | 100 | 7013 | 2394 | 4638 | 1438 | 8898 | 1600 |
| | **Land class** | **FC1** | | **FC2** | | **FC3** | |
| **Species** | **C** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 1 | 73 | 29 | 89 | 28 | 112 | 28 |
| C4 Native | 6 | 440 | 171 | 531 | 167 | 674 | 168 |
| Phalaris | 14 | 1026 | 399 | 1240 | 391 | 1573 | 393 |
| P Rye | 59 | 4324 | 1683 | 5226 | 1647 | 6629 | 1656 |
| Tall Fescue | 7 | 513 | 200 | 620 | 195 | 786 | 196 |
| Paspalum | 1 | 73 | 29 | 89 | 28 | 112 | 28 |
| Brome | 3 | 220 | 86 | 266 | 84 | 337 | 84 |
| Other | 9 | 660 | 257 | 797 | 251 | 1011 | 253 |
| Total | 100 | 7329 | 2853 | 8858 | 2791 | 11236 | 2807 |

Table 18. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 04.01.2011

| | **B.Comp (%)** | **Pasture Biomass (kg DM/ha)** | | | | | |
|---|---|---|---|---|---|---|---|
| | **Land class** | **HA1** | | **HA2** | | **HA3** | |
| **Species** | **A** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 30 | 2480 | 160 | 2128 | 151 | 3472 | 154 |
| C4 Native | 39 | 3223 | 208 | 2767 | 197 | 4514 | 200 |
| White Clover | 1 | 83 | 5 | 71 | 5 | 116 | 5 |
| Paspalum | 23 | 1901 | 123 | 1632 | 116 | 2662 | 118 |
| Other | 7 | 579 | 37 | 497 | 35 | 810 | 36 |
| Total | 100 | 8265 | 534 | 7095 | 504 | 11575 | 513 |
| | **Land class** | **HB1** | | **HB2** | | **HB3** | |
| **Species** | **B** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 50 | 3602 | 286 | 3532 | 270 | 4625 | 212 |
| C4 Native | 44 | 3170 | 252 | 3109 | 238 | 4070 | 187 |
| Tall Fescue | 1 | 72 | 6 | 71 | 5 | 92 | 4 |
| Other | 5 | 360 | 29 | 353 | 27 | 462 | 21 |
| Total | 100 | 7205 | 572 | 7065 | 540 | 9250 | 425 |
| | **Land class** | **HC1** | | **HC2** | | **HC3** | |
| **Species** | **C** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C4 Native | 60 | 7215 | 525 | 8649 | 344 | 3288 | 390 |
| P Rye | 8 | 962 | 70 | 1153 | 46 | 438 | 52 |
| Tall Fescue | 2 | 240 | 18 | 288 | 11 | 110 | 13 |
| Other | 30 | 3608 | 262 | 4324 | 172 | 1644 | 195 |
| Total | 100 | 12025 | 875 | 14415 | 573 | 5480 | 650 |

Table 19. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 04.01.2011

| | B.Comp (%) | Pasture Biomass (kg DM/ha) | | | | | |
|---|---|---|---|---|---|---|---|
| | Land class | FA1 | | FA2 | | FA3 | |
| Species | A | THM | GHM | THM | GHM | THM | GHM |
| C4 Native | 7 | 174 | 125 | 280 | 143 | 177 | 166 |
| P Rye | 29 | 720 | 520 | 1161 | 592 | 735 | 687 |
| White Clover | 1 | 25 | 18 | 40 | 20 | 25 | 24 |
| Brome | 57 | 1416 | 1021 | 2281 | 1165 | 1444 | 1350 |
| Other | 6 | 149 | 108 | 240 | 123 | 152 | 142 |
| Total | 100 | 2484 | 1792 | 4002 | 2043 | 2533 | 2369 |
| | Land class | FB1 | | FB2 | | FB3 | |
| Species | B | THM | GHM | THM | GHM | THM | GHM |
| C4 Native | 40 | 1341 | 958 | 1070 | 575 | 1204 | 640 |
| P Rye | 31 | 1040 | 742 | 829 | 446 | 933 | 496 |
| Tall Fescue | 8 | 268 | 192 | 214 | 115 | 241 | 128 |
| White Clover | 8 | 268 | 192 | 214 | 115 | 241 | 128 |
| Other | 12 | 402 | 287 | 321 | 173 | 361 | 192 |
| Annual Grass | 1 | 34 | 24 | 27 | 14 | 30 | 16 |
| Total | 100 | 3353 | 2394 | 2676 | 1438 | 3009 | 1600 |
| | Land class | FC1 | | FC2 | | FC3 | |
| Species | C | THM | GHM | THM | GHM | THM | GHM |
| C4 Native | 4 | 360 | 114 | 318 | 112 | 243 | 112 |
| Phalaris | 21 | 1889 | 599 | 1672 | 586 | 1275 | 589 |
| P Rye | 7 | 630 | 200 | 557 | 195 | 425 | 196 |
| Tall Fescue | 2 | 180 | 57 | 159 | 56 | 121 | 56 |
| White Clover | 4 | 360 | 114 | 318 | 112 | 243 | 112 |
| Paspalum | 34 | 3058 | 970 | 2707 | 949 | 2064 | 954 |
| Other | 28 | 2518 | 799 | 2229 | 781 | 1700 | 786 |
| Total | 100 | 8993 | 2853 | 7962 | 2791 | 6071 | 2807 |

Table 20. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 01.02.2011

| | **B.Comp (%)** | **Pasture Biomass (kg DM/ha)** | | | | | |
|---|---|---|---|---|---|---|---|
| | **Land class** | **HA1** | | **HA2** | | **HA3** | |
| **Species** | **A** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 30 | 1409 | 160 | 1774 | 151 | 2151 | 154 |
| C4 Native | 39 | 1831 | 208 | 2306 | 197 | 2796 | 200 |
| White Clover | 1 | 47 | 5 | 59 | 5 | 72 | 5 |
| Paspalum | 23 | 1080 | 123 | 1360 | 116 | 1649 | 118 |
| Other | 7 | 329 | 37 | 414 | 35 | 502 | 36 |
| Total | 100 | 4696 | 534 | 5913 | 504 | 7170 | 513 |
| | **Land class** | **HB1** | | **HB2** | | **HB3** | |
| **Species** | **B** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 50 | 2189 | 286 | 2922 | 270 | 2685 | 212 |
| C4 Native | 44 | 1926 | 252 | 2571 | 238 | 2363 | 187 |
| Tall Fescue | 1 | 44 | 6 | 58 | 5 | 54 | 4 |
| Other | 5 | 219 | 29 | 292 | 27 | 268 | 21 |
| Total | 100 | 4378 | 572 | 5843 | 540 | 5370 | 425 |
| | **Land class** | **HC1** | | **HC2** | | **HC3** | |
| **Species** | **C** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C4 Native | 60 | 3125 | 525 | 4263 | 344 | 4276 | 390 |
| P Rye | 8 | 417 | 70 | 568 | 46 | 570 | 52 |
| Tall Fescue | 2 | 104 | 18 | 142 | 11 | 143 | 13 |
| Other | 30 | 1563 | 262 | 2131 | 172 | 2138 | 195 |
| Total | 100 | 5209 | 875 | 7104 | 573 | 7126 | 650 |

Table 21. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 01.02.2011

| | B.Comp (%) | Pasture Biomass (kg DM/ha) | | | | | |
|---|---|---|---|---|---|---|---|
| | Land class | FA1 | | FA2 | | FA3 | |
| Species | A | THM | GHM | THM | GHM | THM | GHM |
| C4 Native | 7 | 367 | 125 | 820 | 143 | 1029 | 166 |
| P Rye | 29 | 1520 | 520 | 3396 | 592 | 4261 | 687 |
| White Clover | 1 | 52 | 18 | 117 | 20 | 147 | 24 |
| Brome | 57 | 2988 | 1021 | 6675 | 1165 | 8376 | 1350 |
| Other | 6 | 315 | 108 | 703 | 123 | 882 | 142 |
| Total | 100 | 5242 | 1792 | 11711 | 2043 | 14695 | 2369 |
| | Land class | FB1 | | FB2 | | FB3 | |
| Species | B | THM | GHM | THM | GHM | THM | GHM |
| C4 Native | 40 | 2354 | 958 | 4695 | 575 | 5899 | 640 |
| P Rye | 31 | 1824 | 742 | 3638 | 446 | 4572 | 496 |
| Tall Fescue | 8 | 471 | 192 | 939 | 115 | 1180 | 128 |
| White Clover | 8 | 471 | 192 | 939 | 115 | 1180 | 128 |
| Other | 12 | 706 | 287 | 1408 | 173 | 1770 | 192 |
| Annual Grass | 1 | 59 | 24 | 117 | 14 | 147 | 16 |
| Total | 100 | 5884 | 2394 | 11737 | 1438 | 14747 | 1600 |
| | Land class | FC1 | | FC2 | | FC3 | |
| Species | C | THM | GHM | THM | GHM | THM | GHM |
| C4 Native | 4 | 681 | 114 | 559 | 112 | 707 | 112 |
| Phalaris | 21 | 3578 | 599 | 2937 | 586 | 3714 | 589 |
| P Rye | 7 | 1193 | 200 | 979 | 195 | 1238 | 196 |
| Tall Fescue | 2 | 341 | 57 | 280 | 56 | 354 | 56 |
| White Clover | 4 | 681 | 114 | 559 | 112 | 707 | 112 |
| Paspalum | 34 | 5793 | 970 | 4755 | 949 | 6013 | 954 |
| Other | 28 | 4770 | 799 | 3916 | 781 | 4952 | 786 |
| Total | 100 | 17037 | 2853 | 13984 | 2791 | 17684 | 2807 |

Table 22. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 08.03.2011

| | **B.Comp (%)** | **Pasture Biomass (kg DM/ha)** | | | | | |
|---|---|---|---|---|---|---|---|
| | **Land class** | **HA1** | | **HA2** | | **HA3** | |
| **Species** | **A** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 30 | 2189 | 160 | 2148 | 151 | 2059 | 154 |
| C4 Native | 39 | 2846 | 208 | 2792 | 197 | 2677 | 200 |
| White Clover | 1 | 73 | 5 | 72 | 5 | 69 | 5 |
| Paspalum | 23 | 1678 | 123 | 1647 | 116 | 1579 | 118 |
| Other | 7 | 511 | 37 | 501 | 35 | 480 | 36 |
| Total | 100 | 7297 | 534 | 7160 | 504 | 6863 | 513 |
| | **Land class** | **HB1** | | **HB2** | | **HB3** | |
| **Species** | **B** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 50 | 2912 | 286 | 2178 | 270 | 3488 | 212 |
| C4 Native | 44 | 2562 | 252 | 1917 | 238 | 3070 | 187 |
| Tall Fescue | 1 | 58 | 6 | 44 | 5 | 70 | 4 |
| Other | 5 | 291 | 29 | 218 | 27 | 349 | 21 |
| Total | 100 | 5823 | 572 | 4357 | 540 | 6977 | 425 |
| | **Land class** | **HC1** | | **HC2** | | **HC3** | |
| **Species** | **C** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C4 Native | 60 | 4876 | 525 | 5316 | 344 | 5054 | 390 |
| P Rye | 8 | 650 | 70 | 709 | 46 | 674 | 52 |
| Tall Fescue | 2 | 163 | 18 | 177 | 11 | 168 | 13 |
| Other | 30 | 2438 | 262 | 2658 | 172 | 2527 | 195 |
| Total | 100 | 8127 | 875 | 8860 | 573 | 8423 | 650 |

Table 23. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 08.03.2011

| | **B.Comp (%)** | **Pasture Biomass (kg DM/ha)** | | | | | |
|---|---|---|---|---|---|---|---|
| | **Land class** | **FA1** | | **FA2** | | **FA3** | |
| **Species** | **A** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C4 Native | 7 | 985 | 125 | 531 | 143 | 1330 | 166 |
| P Rye | 29 | 4081 | 520 | 2201 | 592 | 5509 | 687 |
| White Clover | 1 | 141 | 18 | 76 | 20 | 190 | 24 |
| Brome | 57 | 8021 | 1021 | 4326 | 1165 | 10828 | 1350 |
| Other | 6 | 844 | 108 | 455 | 123 | 1140 | 142 |
| Total | 100 | 14072 | 1792 | 7590 | 2043 | 18997 | 2369 |
| | **Land class** | **FB1** | | **FB2** | | **FB3** | |
| **Species** | **B** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C4 Native | 40 | 6262 | 958 | 2927 | 575 | 5572 | 640 |
| P Rye | 31 | 4853 | 742 | 2268 | 446 | 4319 | 496 |
| Tall Fescue | 8 | 1252 | 192 | 585 | 115 | 1114 | 128 |
| White Clover | 8 | 1252 | 192 | 585 | 115 | 1114 | 128 |
| Other | 12 | 1879 | 287 | 878 | 173 | 1672 | 192 |
| Annual Grass | 1 | 157 | 24 | 73 | 14 | 139 | 16 |
| Total | 100 | 15655 | 2394 | 7317 | 1438 | 13931 | 1600 |
| | **Land class** | **FC1** | | **FC2** | | **FC3** | |
| **Species** | **C** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C4 Native | 4 | 322 | 114 | 577 | 112 | 630 | 112 |
| Phalaris | 21 | 1692 | 599 | 3031 | 586 | 3309 | 589 |
| P Rye | 7 | 564 | 200 | 1010 | 195 | 1103 | 196 |
| Tall Fescue | 2 | 161 | 57 | 289 | 56 | 315 | 56 |
| White Clover | 4 | 322 | 114 | 577 | 112 | 630 | 112 |
| Paspalum | 34 | 2739 | 970 | 4907 | 949 | 5357 | 954 |
| Other | 28 | 2255 | 799 | 4041 | 781 | 4411 | 786 |
| Total | 100 | 8055 | 2853 | 14431 | 2791 | 15755 | 2807 |

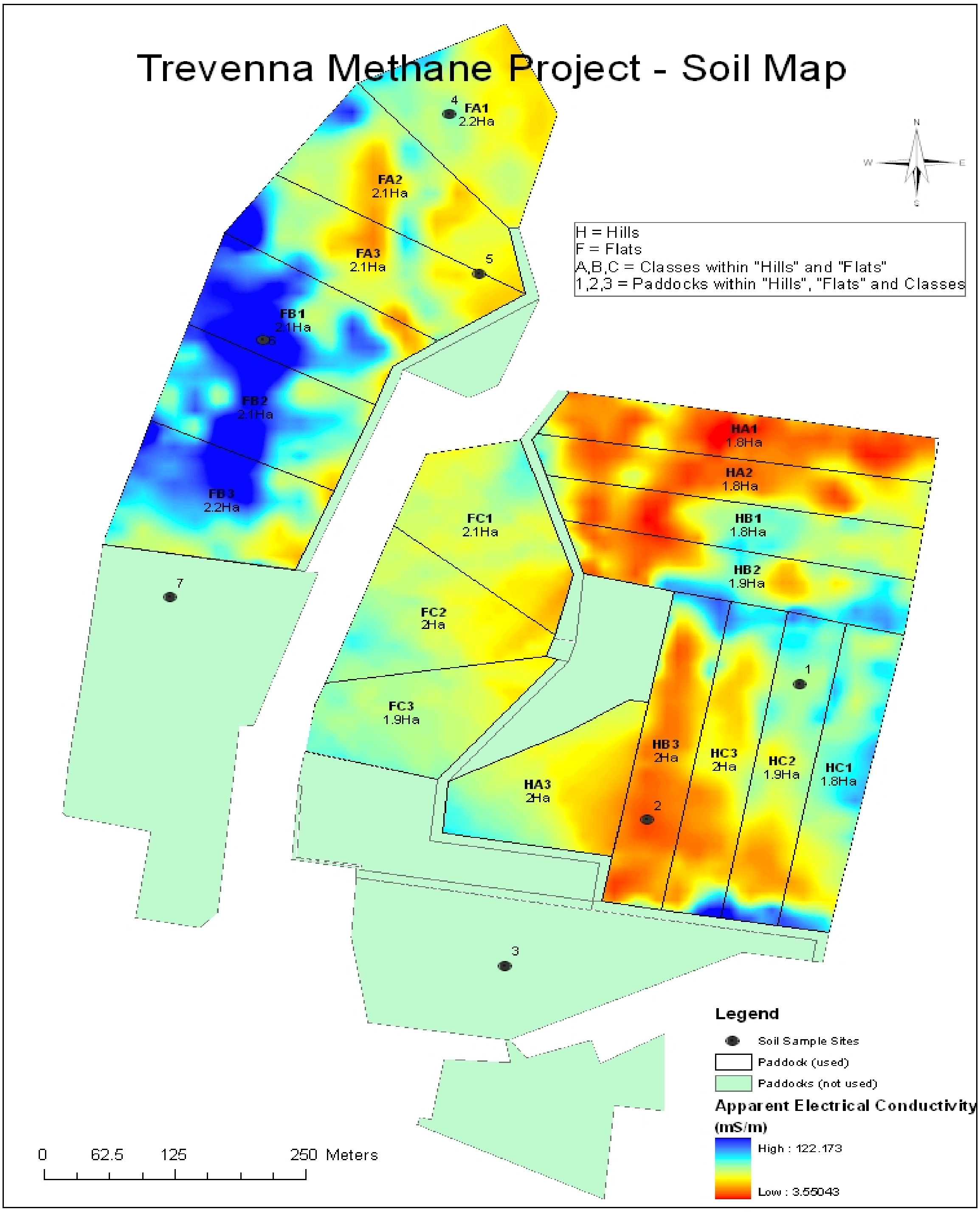
Table 24. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on low productivity landscapes (i.e., on the hills (H)) sampled 20.04.2011

| | B.Comp (%) | Pasture Biomass (kg DM/ha) | | | | | |
|---|---|---|---|---|---|---|---|
| | Land class | HA1 | | HA2 | | HA3 | |
| **Species** | **A** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 30 | 867 | 160 | 1107 | 151 | 1184 | 154 |
| C4 Native | 39 | 1127 | 208 | 1439 | 197 | 1539 | 200 |
| White Clover | 1 | 29 | 5 | 37 | 5 | 39 | 5 |
| Paspalum | 23 | 665 | 123 | 849 | 116 | 908 | 118 |
| Other | 7 | 202 | 37 | 258 | 35 | 276 | 36 |
| Total | 100 | 2890 | 534 | 3690 | 504 | 3947 | 513 |
| | **Land class** | **HB1** | | **HB2** | | **HB3** | |
| **Species** | **B** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C3 Native | 50 | 1888 | 286 | 1962 | 270 | 1978 | 212 |
| C4 Native | 44 | 1662 | 252 | 1726 | 238 | 1741 | 187 |
| Tall Fescue | 1 | 38 | 6 | 39 | 5 | 40 | 4 |
| Other | 5 | 189 | 29 | 196 | 27 | 198 | 21 |
| Total | 100 | 3777 | 572 | 3923 | 540 | 3957 | 425 |
| | **Land class** | **HC1** | | **HC2** | | **HC3** | |
| **Species** | **C** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C4 Native | 60 | 3922 | 525 | 3002 | 344 | 2230 | 390 |
| P Rye | 8 | 523 | 70 | 400 | 46 | 297 | 52 |
| Tall Fescue | 2 | 131 | 18 | 100 | 11 | 74 | 13 |
| Other | 30 | 1961 | 262 | 1501 | 172 | 1115 | 195 |
| Total | 100 | 6537 | 875 | 5003 | 573 | 3717 | 650 |

Table 25. Total herbage biomass (THM) and green herbage biomass (GHM) based on NDVI conversion to biomass (kg DM/ha), botanical composition (01.03.2011) across species for paddocks (1 to 3) within land classes A, B, and C on high productivity landscapes (i.e., on the flats (F)) sampled 20.04.2011

| | **B.Comp (%)** | **Pasture Biomass (kg DM/ha)** | | | | | |
|---|---|---|---|---|---|---|---|
| | **Land class** | **FA1** | | **FA2** | | **FA3** | |
| **Species** | **A** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C4 Native | 7 | 807 | 125 | 1032 | 143 | 1001 | 166 |
| P Rye | 29 | 3344 | 520 | 4276 | 592 | 4147 | 687 |
| White Clover | 1 | 115 | 18 | 147 | 20 | 143 | 24 |
| Brome | 57 | 6573 | 1021 | 8405 | 1165 | 8151 | 1350 |
| Other | 6 | 692 | 108 | 885 | 123 | 858 | 142 |
| Total | 100 | 11531 | 1792 | 14745 | 2043 | 14300 | 2369 |
| | **Land class** | **FB1** | | **FB2** | | **FB3** | |
| **Species** | **B** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C4 Native | 40 | 4186 | 958 | 5606 | 575 | 2749 | 640 |
| P Rye | 31 | 3244 | 742 | 4344 | 446 | 2130 | 496 |
| Tall Fescue | 8 | 837 | 192 | 1121 | 115 | 550 | 128 |
| White Clover | 8 | 837 | 192 | 1121 | 115 | 550 | 128 |
| Other | 12 | 1256 | 287 | 1682 | 173 | 825 | 192 |
| Annual Grass | 1 | 105 | 24 | 140 | 14 | 69 | 16 |
| Total | 100 | 10466 | 2394 | 14014 | 1438 | 6872 | 1600 |
| | **Land class** | **FC1** | | **FC2** | | **FC3** | |
| **Species** | **C** | **THM** | **GHM** | **THM** | **GHM** | **THM** | **GHM** |
| C4 Native | 4 | 375 | 114 | 397 | 112 | 316 | 112 |
| Phalaris | 21 | 1970 | 599 | 2086 | 586 | 1659 | 589 |
| P Rye | 7 | 657 | 200 | 695 | 195 | 553 | 196 |
| Tall Fescue | 2 | 188 | 57 | 199 | 56 | 158 | 56 |
| White Clover | 4 | 375 | 114 | 397 | 112 | 316 | 112 |
| Paspalum | 34 | 3190 | 970 | 3378 | 949 | 2686 | 954 |
| Brome | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 28 | 2627 | 799 | 2782 | 781 | 2212 | 786 |

## Example of a Normalized Difference Vegetation Index (NDVI) map produced for each scan




Normalized Difference Vegetation Index (NDVI) of Trevenna paddocks taken on the 18th October 2010 for the hills (H) (low fertility) and flats (F) (high fertility) landscape and their classes (A, B, and C) within the landscapes at the Trevenna on-farm methane emissions demonstration site, Armidale Note: the lower the NDVI index the lower the pasture biomass available

Tables 26 to 30 details of animal productivity in 2010-2011 and the results of the pseudo slaughter in April 2011 and March 2012.

Table 26. Ewe weights (kg) across flocks on low and high productivity landscapes in year 1; mean (±SD)

| | **Low productivity Flocks** | | | **High productivity Flocks** | | |
|---|---|---|---|---|---|---|
| **Date** | **1** | **2** | **3** | **4** | **5** | **6** |
| 21.07.2010 | 40.77 (2.91) | 41.07 (4.39) | 40.93 (3.43) | 40.87 (3.60) | 41.55 (3.69) | 40.92 (3.49) |
| 02.09.2010 | 43.00 (5.15) | 44.98 (3.17) | 46.60 (2.97) | 44.11 (4.38) | 45.50 (3.97) | 44.52 (4.01) |
| 19.10.2010 | 39.20 (4.05) | 39.13 (2.23) | 42.26 (4.01) | 45.29 (4.67) | 45.49 (4.82) | 42.84 (5.14) |
| 11.11.2010 | 40.16 (4.52) | 42.60 (2.54) | 45.25 (3.68) | 43.25 (4.94) | 46.38 (5.05) | 47.61 (5.72) |
| 8.12.2010 | 42.33 (4.11) | 40.58 (2.98) | 43.46 (4.07) | 41.14 (3.81) | 42.55 (5.39) | 42.10 (5.01) |
| 4.01.2011 | 43.86 (4.00) | 43.05 (2.97) | 45.46 (3.78) | 45.55 (3.83) | 46.37 (4.34) | 45.14 (5.47) |
| 2.02.2011 | 44.59 (4.34) | 43.96 (3.34) | 46.52 (3.77) | 46.40 (4.92) | 50.37 (5.64) | 46.61 (5.55) |
| 8.03.2011 | 46.90 (4.71) | 45.86 (3.35) | 46.72 (5.34) | 45.06 (4.78) | 48.09 (4.47) | 46.92 (5.45) |
| 5.04.2011 | 46.48 (4.73) | 47.44 (3.49) | 48.05 (4.17) | 50.09 (4.71) | 47.58 (9.97) | 46.54 (5.22) |
| 15.04.2011 | 44.23 (4.61) | 44.74 (3.58) | 44.23 (3.46) | 47.84 (4.72) | 48.58 (4.77) | 47.94 (5.45) |

Table 27. Lamb weights (kg) across flocks on low and high productivity landscapes in year 1; mean (±SD)

| | **Low productivity Flocks** | | | **High productivity Flocks** | | |
|---|---|---|---|---|---|---|
| **Date** | **1** | **2** | **3** | **4** | **5** | **6** |
| 8.10.2010 | 14.96 | 13.73 | 13.45 | 12.73 | 13.17 | 13.41 |
| | (2.73) | (2.84) | (2.50) | (3.30) | (2.73) | (2.39) |
| 11.11.2010 | 20.55 | 18.75 | 20.59 | 19.77 | 20.26 | 20.88 |
| | (2.38) | (3.43) | (2.06) | (3.64) | (2.62) | (2.79) |
| 8.12.2010 | 25.84 | 23.61 | 26.34 | 25.08 | 25.63 | 26.75 |
| | (2.73) | (3.55) | (2.15) | (3.78) | (2.76) | (2.76) |
| 4.01.2011 | 31.15 | 28.26 | 31.50 | 32.22 | 32.03 | 32.37 |
| | (2.98) | (4.64) | (2.74) | (4.37) | (3.34) | (2.98) |
| 02.02.2011 | 31.73 | 29.49 | 33.74 | 37.20 | 34.59 | 36.27 |
| | (2.86) | (4.47) | (3.21) | (4.56) | (3.24) | (2.97) |
| 8.03.2011 | 35.87 | 31.33 | 38.00 | 39.14 | 38.37 | 39.82 |
| | (4.85) | (5.33) | (3.70) | (4.42) | (3.09) | (3.39) |
| 4.04.2011 | 37.01 | 33.00 | 39.91 | 44.54 | 40.52 | 38.60 |
| | (3.95) | (5.86) | (3.62) | (4.74) | (3.11) | (7.99) |

Table 28. Greasy wool production data for year 1 (July 2010) across flocks on low and high productivity landscapes; mean (±SD)

| | **Low productivity Flocks** | | | **High productivity Flocks** | | |
|---|---|---|---|---|---|---|
| **Date** | **1** | **2** | **3** | **4** | **5** | **6** |
| Fleece.wt. | 2.67 | 3.07 | 3.15 | 2.87 | 2.88 | 2.97 |
| | (0.37) | (0.72) | (0.66) | (0.47) | (0.44) | (0.48) |
| Staple.length | 81.83 | 80.00 | 79.40 | 79.94 | 77.89 | 79.67 |
| | (11.43) | (11.44) | (7.70) | (8.59) | (12.63) | (8.10) |
| Staple.strength | 37.31 | 40.80 | 33.88 | 35.61 | 36.85 | 39.18 |
| | (6.47) | (10.50) | (9.74) | (7.14) | (7.02) | (6.60) |
| Fibre.diameter | 16.67 | 16.12 | 16.67 | 16.51 | 16.33 | 16.33 |
| | (1.10) | (1.21) | (1.50) | (0.94) | (1.57) | (1.10) |

Table 29. Production data at pseudo slaughter date (4.04.2011) across flocks for low and high productivity landscapes; mean (±SD)

| | Low productivity Flocks | | | High productivity Flocks | | |
|---|---|---|---|---|---|---|
| **Date** | **1** | **2** | **3** | **4** | **5** | **6** |
| Eye.Muscle.Area ($mm^2$) | 24.36 (2.59) | 19.38 (3.69) | 23.79 (2.29) | 24.94 (2.87) | 24.90 (2.51) | 24.66 (2.88) |
| Fat.Depth (mm) | 2.50 (1.00) | 1.63 (0.52) | 2.57 (0.90) | 3.02 (0.66) | 2.58 (0.71) | 2.97 (0.93) |
| GR (mm) | 10.21 (3.14) | 7.69 (2.75) | 10.14 (2.44) | 12.58 (2.16) | 12.00 (1.71) | 12.55 (2.41) |
| Carcass.Weight (kg) | 16.59 (2.16) | 13.79 (2.69) | 17.09 (1.92) | 18.06 (2.05) | 17.62 (1.40) | 18.28 (1.66) |
| Dressing Percent (%) | 45.10 (1.54) | 43.82 (1.82) | 44.92 (1.11) | 46.14 (1.08) | 45.92 (0.88) | 46.04 (1.12) |

Table 30. Production data at pseudo slaughter date (6.03.2012) across flocks for low and high productivity landscapes; mean (±SD)

| | Low productivity Flocks | | | High productivity Flocks | | |
|---|---|---|---|---|---|---|
| **Date** | **1** | **2** | **3** | **4** | **5** | **6** |
| Eye.Muscle.Area ($mm^2$) | 25.24 (2.88) | 25.28 (2.05) | 23.11 (2.00) | 24.03 (2.47) | 24.43 (1.96) | 24.39 (2.13) |
| Fat.Depth (mm) | 2.18 (0.58) | 2.22 (0.60) | 2.06 (0.42) | 1.97 (0.36) | 2.04 (0.39) | 2.30 (0.64) |
| GR (mm) | 4.73 (1.75) | 4.87 (1.80) | 4.37 (1.25) | 4.12 (1.07) | 4.33 (1.17) | 5.11 (1.93) |
| Carcass.Weight (kg) | 15.72 (2.02) | 16.64 (1.93) | 15.65 (1.73) | 15.25 (1.71) | 15.33 (1.61) | 16.15 (2.14) |
| Dressing Percent (%) | 42.08 (0.99) | 42.15 (0.94) | 41.90 (0.71) | 41.76 (0.61) | 41.88 (0.64) | 42.27 (1.03) |

## FTIR Results

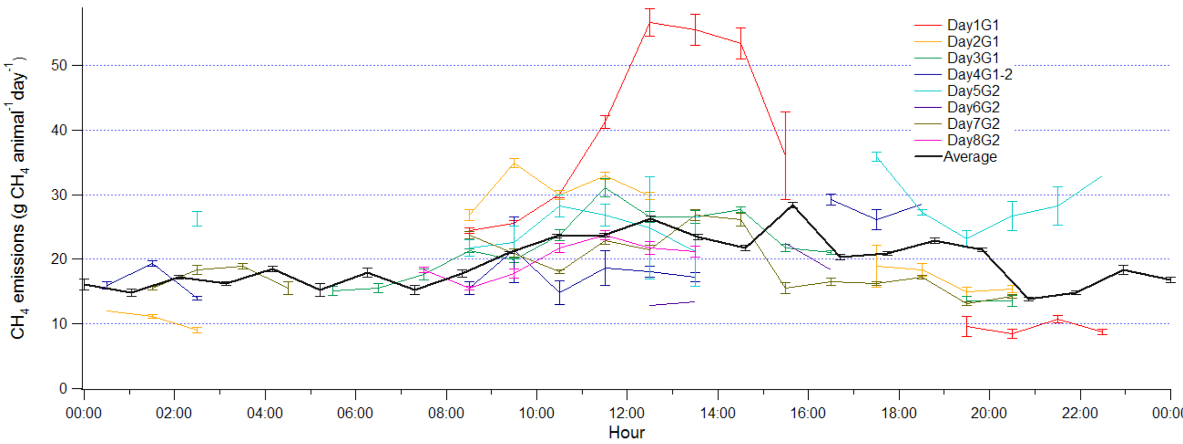



Figure 2. Methane emissions (g CH4/animal/day) using FTIR technology over a 24 hour period on the low productivity landscape; black solid line is the average not including the Day1G1 readings (red). (Pers. Comm. Dr Frances Phillips BCCH 1036)

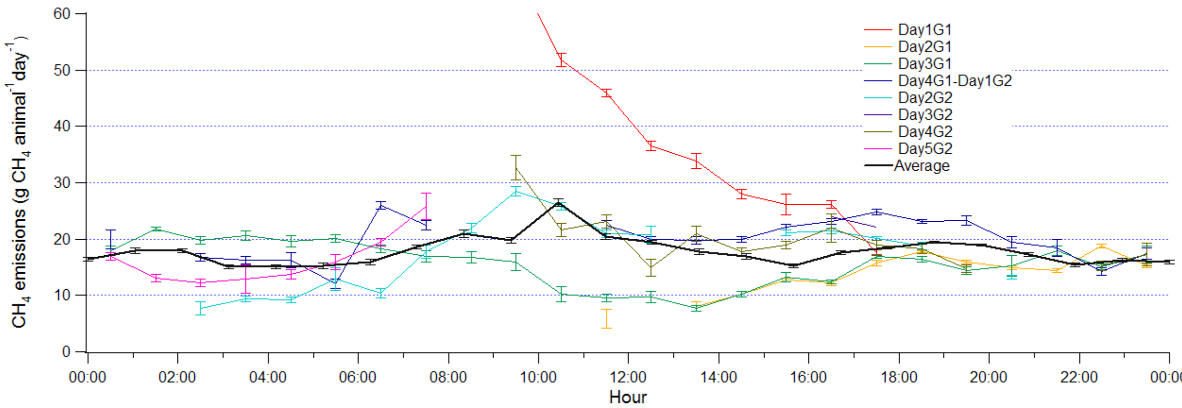



Figure 3. Methane emissions (g CH4/animal/day) using FTIR technology over a 24 hour period on the high productivity landscape; black solid line is the average including all readings for each day. (Pers. Comm. Dr Frances Phillips BCCH 1036)

Figures 2 and 3 report the results of the FTIR study and Table 31 summaries the estimated methane output from low and high productivity landscapes.

Table 31. Stock numbers, area, green and dead digestibility, and methane output from FTIR experiment; mean (± SD). Date

| | | | Stock | | Biomass | | |
|---|---|---|---|---|---|---|---|
| | Pdk area ($m^2$) | Days In Pdk | Ewes | Lambs | Green | Dead | CH4 (g/animal/day) |
| Low | 0.13 | 1.95[3] | 16 | 15.5[1] | 54.0 (1.41) | 47.0 (6.98) | 19.5 ( )[2] |
| High | 0.13 | 1.75[3] | 32 | 31 | 65.8 (4.92) | 54.8 (4.50) | 17.5 ( )[2] |

1. Averaged over 2 flocks measured 2 times (n=4)
2. Variation not available; methods related to variability being analysed
3. Rotated between 2 paddocks with 2 days in each paddock (n=4)

**Summary of nitrous oxide emissions**

Four static sealed chambers were installed in each of 6 paddocks at the Trevenna livestock methane emissions trial at the University of New England in March 2011. Sampling of the chambers was undertaken on 3 consecutive days approximately 3 days after rainfall in mid-March 2011, and on one day in August 3 days after rainfall. Static chambers invariably throw up gas concentration results that are not linearly related to emissions for nitrous oxide and methane, whilst carbon dioxide measurements display strong linearity. Consequently, when linear regression of change in chamber gas concentrations were lower than 0.5, those values were discarded. As the processing of the data from March was delayed until after the sample collection in August, we remained unaware of the number and significance of null values for methane and nitrous oxide measurements in static chambers. One day's worth of data collection is not enough to be confident that the site gas flux has been captured successfully. Values shaded in red were not used because they failed to pass the linear regression test, and values presented in italics were considered outliers and not used in the calculation of means and standard errors.

On average, nitrous oxide emissions were 4 times higher on the more fertile and productive flats **(20 µg $N_2O/m^2/h$)** than the less fertile hilly country **(5 µg $N_2O/m^2/h$)** in autumn, but 13 times higher (13 µg $N_2O/m^2/h$) in winter when the C4 dominated pasture species on the hills (1 µg $N_2O/m^2/h$) were dormant. As emissions are related to soil solution nitrate, and soil moisture and temperature conditions, it is unsurprising that higher emissions were observed in the more fertile and productive system. Relative productivity was confirmed through $CO_2$ emissions on the flats that were more than double those on the hills over the same sampling period in autumn and 4 times higher in winter. Over the sampling period there was no difference in soil methane emissions between sites.

**Water balance**

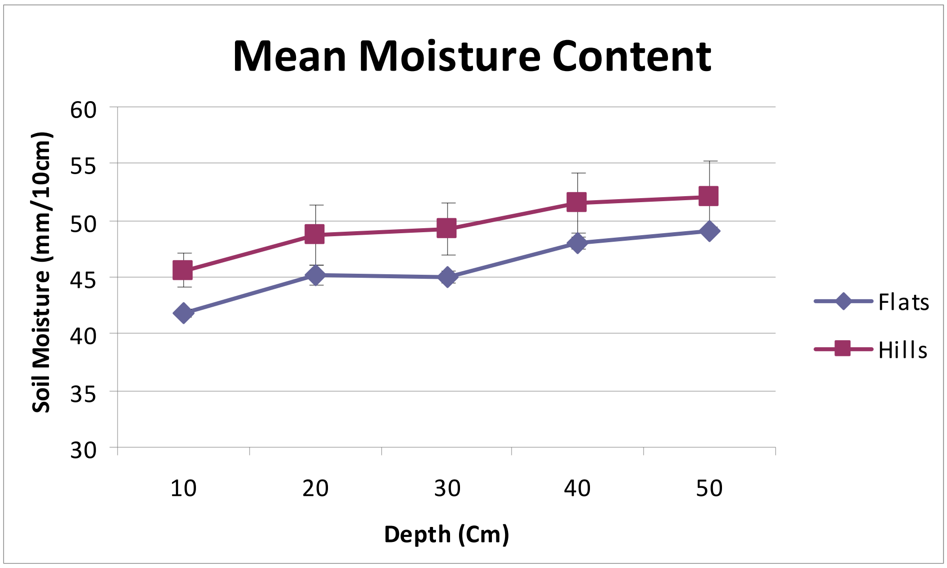



Figure 4. Mean soil moisture content (mm/10cm) at a range of soil depots from 10 to 50 cm for low (hills) and high (flats) productivity landscapes averaged across 4 sampling times (19/07/2011, 29/07/2011, 08/08/2011, 12/08/2011) and 3 paddocks for each landscape

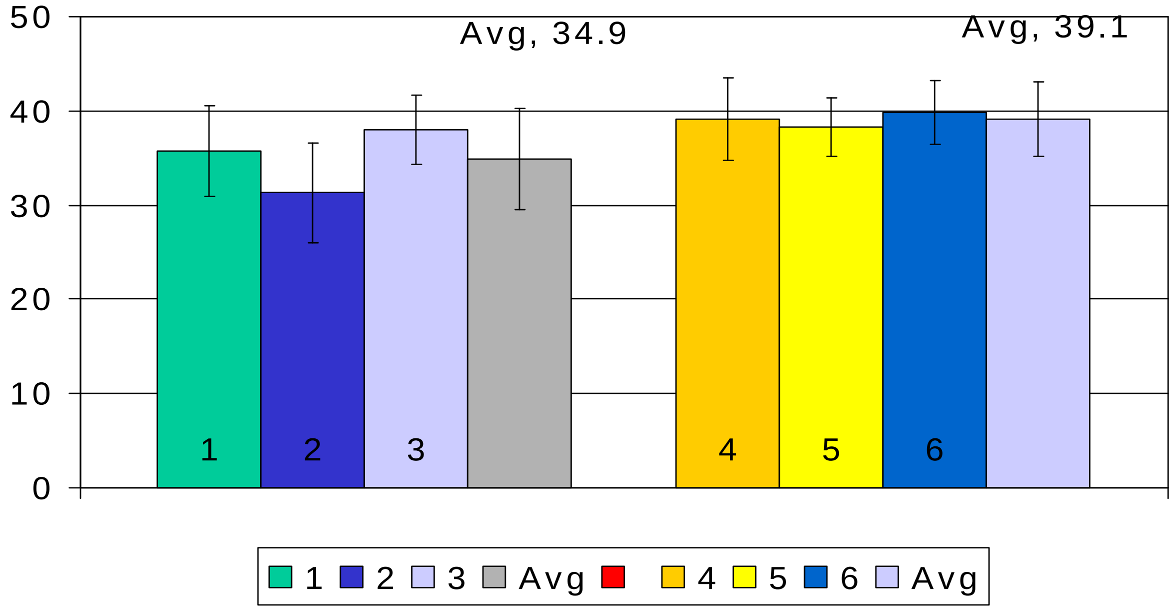



Figure 5. Year 1 lamb live weight (kg) @ Slaughter on 10th March 2011

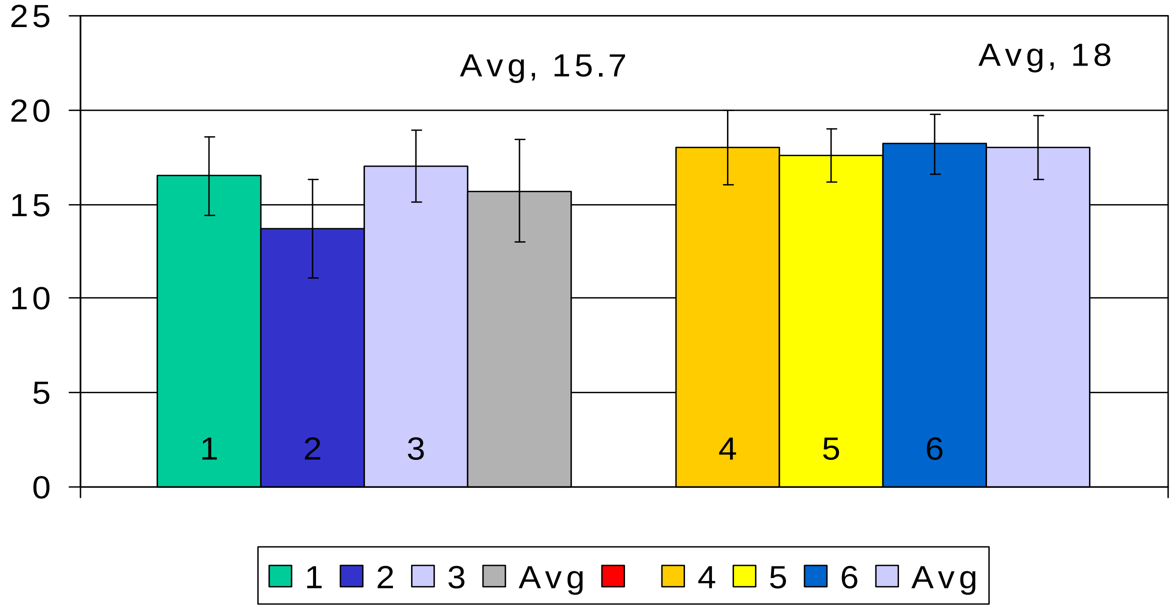



Figure 6. Year 1 lamb carcass weight (kg) @ Slaughter on 10th March 2011

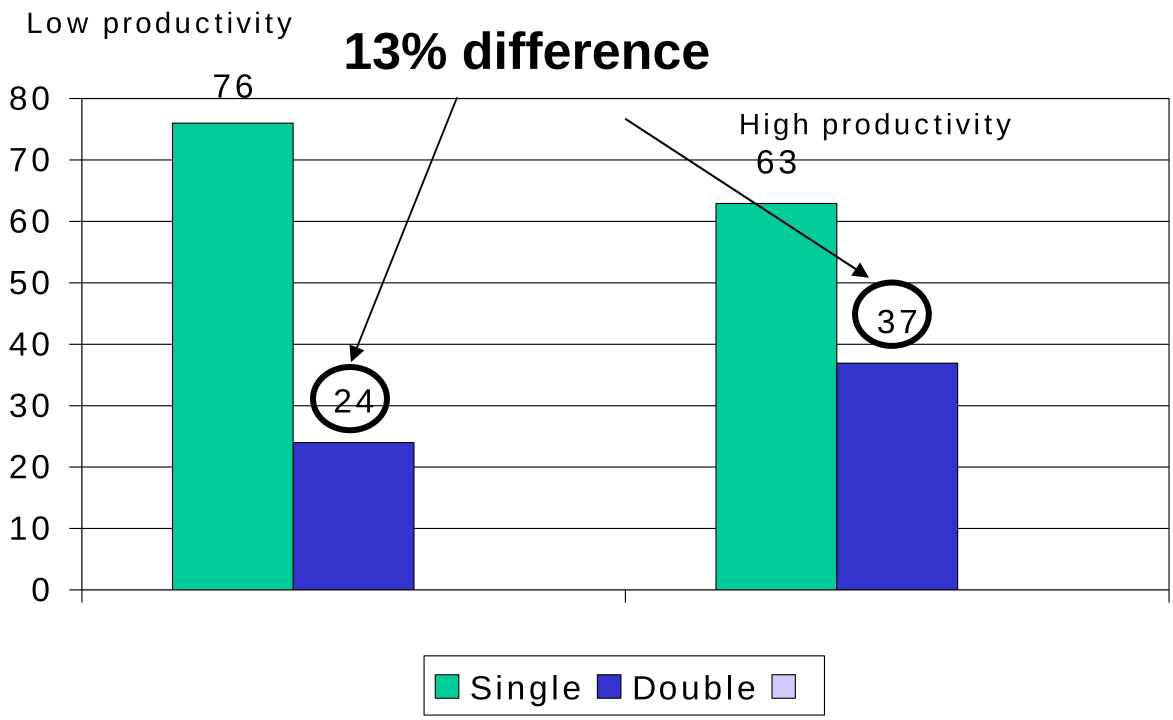



Figure 7. Year 2 pregnancy scans single (%) versus twins (%) across landscape

**Relevant appendices**

1. Press release before the Field day on the 29th March
2. Press release after the Field day on the 29th March – Article to go in the Land
3. ABC interview with Adam Scot broadcasted on the Country Hour on the 1st April.
4. Update on Trevenna as a handout to producers on the Field Day on the 29th March.
5. Trevenna advertising for the field day.

6. Abstract presented at the CCRSPI Conference 15-17th, Melbourne. McPhee MJ, C Edwards, J Meckiff, N Ballie, D Schneider and R Hegarty (2011). Preliminary results of estimating on-farm methane emissions for sheep production on the Northern Tablelands of Australia. CCRSPI The National Climate Change Research Strategy for Primary Industries Conference Melbourne 15-17th February, p. 42
7. Grassland Society of NSW paper
8. APEN abstract
9. AFBM paper
10. Summary of Media Releases.

1. Press release before field day on the 29th March 2011

NSW GOVERNMENT | Industry & Investment **Media Release**

Date

## Producers learn about methane at demonstration site

Northern Tablelands producers will have the opportunity to learn about livestock methane at the Trevenna demonstration site at a field day on Tuesday 29 March.

The Trevenna demonstration site is located at the University of New England (UNE) and has been set up to give producers a practical insight into carbon flows, especially methane production from crossbred lambs.

The UNE site is focusing on low and high intensity sheep grazing systems on the Northern Tablelands.

The field day will provide a general background on livestock emissions, the purpose of measurements currently being undertaken, and demonstrate some of the ways the experiment is measuring and predicting methane.

"The focus of the field day is to help producers understand some of the basic principles of livestock in the carbon cycle, how that can be married with improved productivity and how the demonstration site is collecting that information," Industry & Investment NSW (I&I NSW) researcher Dr Malcolm McPhee said.

There will be demonstrations of:

- the open-path infrared scanning technology to measure methane emissions
- precision agriculture scanning of pasture biomass
- measuring soil water availability
- measuring nitrous oxide emissions"

Dr McPhee said speakers include the newly appointed Professor of Animal Nutrition from UNE Dr Roger Hegarty who is an internationally recognized expert on methane emissions.

"This is a joint project between I & I NSW and the UNE, supported by Meat and Livestock Australia, through funding from the Australian Government's Climate Change Research Program," Dr McPhee said.

"The Australian Government is investing $46.2 million in taking research from the lab to the paddock to help farmers to be profitable, sustainable and resilient in a changing climate for Australia's Farming Future.

"The Trevenna demonstration site is one of four sites across Australia and this site on the Northern Tablelands reinforces the significant contribution that producers make on the Northern Tablelands to agricultural production."

The day will start at 9:30am on Tuesday 29 March 2011 at the Trevenna Glasshouse Complex located near the western car park at University of New England.

The morning session will be followed by a free lunch and a field walk in the afternoon. The field day will conclude at 2pm.

For more information and to RSVP *for* catering contact the I&I NSW Armidale district office on 6738 5000 or jim.meckiff@industry.nsw.gov.au

**Media contact: Howard Spencer 02 66568825 or mobile 0428696672**

2. Press release after field day on the 29th March 2011

NSW GOVERNMENT | Industry & Investment

# Media Release

Date

**Armidale sheep flock part of real life study**

Sheep in a flock near Armidale have become the latest stars of much more than a reality television show.

They are part of a real life demonstration site dedicated to investigating methane mitigation strategies for ruminant livestock.

The site, at Trevenna on the west of the University of New England (UNE) campus, is one of four in Australia currently involved in the ruminant project.

"This demonstration will equip graziers with the knowledge, tools and strategies to manage and understand on-farm emissions from sheep production," said Industry & Investment NSW (I&I NSW) research scientist Dr Malcolm McPhee.

"Reducing methane in sheep and cattle is not just good for reducing greenhouse gases; it is also good for producer's bottom lines.

"If we can reduce methane in the gut, sheep or cattle may convert more of their food intake into protein and thus meat yield for producers.

"This site will demonstrate the contrasting productivity of greenhouse gas emissions from low fertility versus high fertility sheep grazing systems.

"The Trevenna site demonstrates that farmers can reduce methane now for every kilo of lamb produced. By providing farmers with methods to predict methane the project will also assist producers be alert to potential opportunities and liabilities in a carbon economy."

The 36ha site was established in March last year.

It is a joint project between I&I NSW and UNE with support from Meat and Livestock Australia and Australian Government's Climate Change Research Program

The Cooperative Research Centre for Spatial Information undertook soil mapping and fencing where the block was cut into equal areas of high fertility with improved pasture on creek flats and low fertility with natural and native pasture on the hills.

Single bearing Merino ewes joined to Border Leicester rams were selected from the UNE research flock.

"The entire site is being measured throughout the two-year life of the demonstration," Dr McPhee said.

"Field days will be held for livestock producers to demonstrate the results of the study."

The first was held on 29 March.
The measurements of the site will include:

- Climate: rainfall, temperature and evaporation
- Soils: nutrients, carbon, Nitrous oxide, soil water, soil structure
- Pastures: pasture composition, herbage mass, quality, percentage green
- Animals: live weight, condition score, wool information, faecal egg counts, methane production
- Economics: cost scenarios, electricity, fuel

"Methane production in animals is essentially a waste of energy that could be converted into meat protein," Dr McPhee said.

"If we can provide producers with a set of tools to better manage farming systems and animals for methane reduction, we are increasing their yields and profits as well as contributing to reducing greenhouse gas."

**Media contact: Howard Spencer 02 66568825 or mobile 0428696672**

4. Update on Trevenna as a handout to producers on the Field Day on the 29th March.

**Project No: B.CCH.1033**

**Demonstration projects from On-farm practical methane management strategies: Trevenna.**


**Summary**

A 36 hectare site at the University of New England, Armidale on the Northern Tablelands of NSW has been established to demonstrate the magnitude of carbon fluxes, especially methane ($CH_4$), associated with crossbred lamb production. This is a joint project with Meat and Livestock Australia and the Australian Government's Climate Change Research Program. Field days for livestock producers will be conducted to demonstrate the results of this study and the techniques employed to measure $CH_4$ (e.g., open-path Fourier-transform infrared spectrometer technology). A soil map and 7 soil samples have been used to characterize the site: it contains soil and topographical diversity typical of the region (pH 4.8 – 5.1 (1:5 CaCl2); soil organic carbon 1.2 – 3.8 (%); cation exchange capacity 3 - 41(meq/100g)). The replicated study over 2 years will compare animal productivity and emissions of low stocking rate enterprises on a low fertile landscape (hills) (16 ewes/paddock) versus a high fertile landscape (flats) (32 ewes/paddock); (Figure 1) at 3.7 and 6.7 dry sheep equivalents (DSE)/ha, for hills and flats respectively. Data will be analysed in terms of methane (g) produced/kg lean meat and kg of wool produced. Pasture biomass, botanical composition, image analysis of pasture, water holding capacity, nitrous oxide ($N_2O$) and animal production data (live weight gain, fat score, fecundity, wool and lamb carcass weights at slaughter) will be collected. Decision support tools (e.g. EcoMod and AusFarm®) will be used to estimate total on-farm $CH_4$ and the collated data will be used in life cycle and economic analyses. Preliminary results (Table 1) of estimating $CH_4$ on the low and high fertility landscapes are reported.


(a) (b)

**Figure 1.** Supplementary feeding during lambing on (a) the hills (low fertility) and (b) the flats (high fertility) (Photo J Meckiff 2010)

**Table 1.** Methane ($CH_4$) produced (g)/kg live weight gain (LWG) from lambs @ 91 days on the hills and flats (24 hour prediction from GrazFeed™) [December 2010 Pasture]

| | Green (t DM/ha) | Dead (t DM/ha) | DMI (kg/day) | | Lambs | | |
|---|---|---|---|---|---|---|---|
| | | | Ewes | Lambs | LWG (g/day) | $CH_4$(g)/ day | $CH_4$(g)/ kg LWG |
| Hills | 1.4 | 4.59 | 1.42 | 0.92 | 133 | 21 | 161 |
| Flats | 4.1 | 4.91 | 1.53 | 0.99 | 174 | 22 | 125 |

5. Trevenna advertising

# Trevenna Field Day
# Grass, Ground and Gas

- a demonstration site investigating on-farm methane management strategies

Tuesday 29th March 2011

9.30am – 2.00pm

Trevenna Potting Shed - Western car park
University of New England

- See the demonstration site and how researchers are estimating greenhouse gases from a sheep enterprise
- See some of the latest equipment in measuring soils, pastures, livestock and methane
- Hear from industry experts about methane and the farm carbon cycle

Lunch provided


For more information (including directions) and RSVP (for catering by Friday 25th March)

I&I NSW District Office **6738 8500** or Jim Meckiff jim.meckiff@industry.nsw.gov.au

NSW GOVERNMENT Industry & Investment

une University of New England

mla MEAT & LIVESTOCK AUSTRALIA

Australian Government Department of Agriculture, Fisheries and Forestry

## 6. Preliminary results of methane emissions from sheep production on the Trevenna demonstration site at UNE presented at Primary Industries Innovation Centre symposium at DUVAL college.

### Preliminary results of methane emissions from sheep production on the Trevenna demonstration site at UNE

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**Purpose of the work**

Agricultural emissions comprise 16% of Australia's total emissions and livestock contribute 69% of agricultural emissions (Department of Climate Changes and Energy Efficiency, 2010). While there is no intent to directly include agricultural emissions in a future national emission trading system, downstream penalisation on agricultural commodities is feasible and, more favourably, there may be opportunity for mitigation of agricultural emissions to provide a carbon offset market (Australian Farm Institute, 2010). Therefore an increasing need exists to provide information to livestock producers e.g. estimates of on-farm emissions and opportunities for on-farm emissions mitigation.

A 36 hectare demonstration site at Trevenna, UNE, Armidale on the Northern Tablelands, NSW has been established to give livestock producers a practical insight into the magnitude of carbon fluxes, especially methane ($CH_4$), associated with crossbred lamb production between 2 contrasting landscapes [hills (18ha) and flats (18 ha)]. A range of decision support tools (DST), calculators and the open-path Fourier-transform infrared (FTIR) spectrometer technology are being used to estimate $CH_4$ and comparisons will be made between the DST, FTIR technology, and calculators.

This study reports the results of (1) the estimate of $CH_4$/live weight gain (LWG) of lambs at 39 days of age using GrazFeed™ (Freer *et al.* 1997); and (2) a whole-paddock simulation to estimate $CH_4$ production of ewes and lambs from birth to slaughter using the SGS (Johnson *et al.* 2003) model.

**Approach**

The design of the experimental site including, animals and pasture species have been fully described (McPhee *et al.* 2011). In brief, 3 flocks of Merino sheep grazing with their weaned progeny (Border Leicester sires) were grazed at a low intensity (3.7 DSE/ha; 16 ewes/paddock plus lambs) on the hills and 3 flocks on a high intensity (6.7 DSE/ha; 32 ewes/paddock plus lambs) on the flats. Flocks were rotated monthly between paddocks (~2 ha), with each flock being allocated to 3 paddocks. The pastures on the hills had a reduced fertiliser history, predominately native pastures and a lower land-use class and the pasture on the flats were situated on creek flats with an improved pasture base. Monthly pasture (green and dead Dry Matter availability and pasture quality); image analysis data from Crop Circle (Holland Scientific equipment model ACS210) scans and regular production data (LWG, fat score, fecundity, wool and lamb carcass weights at slaughter) were collected.

**Results**

Results from the 24 hour estimate of $CH_4$/LWG (g/kg LWG) and from the SGS simulation from the 9th Sept 2010 to 21st March 2011 for paddock HA3 on the hills and paddock FA2 on the flats are reported in Table 1.

**Table 1.** GrazFeed™ results for lambs at 39 days of age and SGS results from 9th Sept 2010 to 21st March 2011 of methane ($CH_4$) production on the hills (HA3) and the flats (FA2) for 1 paddock

| Variable | Hills | Flats |
|---|---|---|
| Area (ha) | 2 | 2.1 |
| No Ewes | 16 | 32 |
| No. Lambs | 16 | 32 |
| DSE/ha | 3.7 | 6.7 |
| ***GrazFeed™ 24 hour est. @ 39 days of age[1]*** | | |
| CH4 (gC)/ kg LWG | 161 | 125 |
| ***SGS simulation from 9th Sept 2010 to 21st March 2011*** | | |
| Ewes grazing (days) | 119 | 119 |
| Lambs at foot (days) | 60 | 60 |
| Pasture intake (t/ha/year) | 2.28 | 3.79 |
| $N_2O$ emission (kgN/ha/year) | 0.29 | 0.4 |
| Stock CO2 (tC/ha/year) | 0.32 | 0.78 |
| Stock $CH_4$ (tC/ha/year) | 0.20 | 0.40 |

1. Green pasture available was hills= 0.77 and flats= 2.23 t DM/ha

## Application

This study demonstrates (1) the methods used to estimate $CH_4$ (e.g. open-path FTIR spectrometer technology and decision support tools e.g. GrazFeed™ and SGS); (2) that $CH_4$ production/LWG is less when grazed on a highly fertile landscape; and (3) calculations of emissions from a whole-farm system.

## Conclusions

Methane estimates over a 24 hour period from GrazFeed™ indicate that $CH_4$ produced per LWG was lower on the flats than on the hills and therefore suggests that management strategies could be put in place now to reduce methane emissions and also increase production which results in a win-win position; heavier live weights and less methane. GrazFeed™ is readily available for producers and many have purchased GrazFeed™ after attending a PROGRAZE course (Bell and Allan 2000). It is an easy package to use and therefore producers could use GrazFeed™ to estimate $CH_4$ emissions over a 24 hour period. The SGS simulation provides an estimate over a longer period and a 50 year simulation will be applied to the Trevenna demonstration site.

## References

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Bell AK, Allan CJ 2000, PROGRAZE - an extension package in grazing and pasture management. *Australian Journal of Experimental Agriculture* **40**, 325-330.

Freer M, Moore AD and Donnelly JR 1997, 'GRAZPLAN: Decision support systems for Australian grazing enterprises--II. The animal biology model for feed intake, production and reproduction and the GrazFeed DSS'. *Agricultural Systems,* **54**: 77-126.
Johnson IR, Lodge GM and White RE 2003, 'The sustainable grazing systems pasture model: description, philosophy and application to the SGS national experiment', *Australian Journal of Experimental Agriculture,* **43**: 711-728.
McPhee MJ, Edwards C, Meckiff J, Ballie J, Schneider D, Arnott P, Cowie A, Savage D, Lamb D, Guppy C, McCorkell B and Hegarty R 2010, Estimating on-farm methane emissions for sheep production on the Northern Tablelands: establishment of demonstration site. *Australian Farm Business Management Journal*, **7:2** 85-94.

7. Grassland society abstract

## Trevenna sheep production demonstration site of methane emissions on the Northern Tablelands of NSW.

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**Abstract**

A demonstration site investigating two production systems for crossbred lambs is currently being evaluated for methane emissions at 'Trevenna' Armidale, NSW. The site will give producers and researchers a practical insight into the carbon cycle, in particular methane.
The replicated study over two years compares animal productivity and emissions of low fertility and low stocking rates (the hills) with a high fertility and higher stocking rate (the flats). Initial set up characterised the two sites and allowed for their subdivision. Extensive measurements of the pastures and livestock are being made. Other measurements being recorded, include soil water, nitrous oxide and weather data. Analysis of the systems will be investigated using four decision support tools. The site will also enhance knowledge of methane in terms of farm carbon and productivity to Northern Tablelands producers and researchers.

**Introduction**

A 36 ha demonstration site based at the University of New England's 'Trevenna' property, on the Northern Tablelands of NSW (30° 28'57.28"S, 151°38'2.47"E) has been established. It is one of four national sites across Australia that has been established in collaboration with Meat and Livestock Australia and the Australian Government's Climate Change Research Program to demonstrate potential mitigation strategies for enteric emissions. It is a joint project between Industry and Investment NSW and the University of New England.

The Trevenna project will equip Northern Tablelands producers and researchers with knowledge and tools in understanding their on-farm sheep production emissions. It will demonstrate the lifecycle of greenhouse gas emissions in sheep grazing enterprises, contrast two sheep grazing systems in different landscapes, and show different methods of predicting and measuring on-farm methane production. Decision support tools will also be used to estimate methane emissions from the site. The site will also be a training facility for undergraduate and postgraduate students in their understanding and learning about on-farm emissions, lifecycle measurements and whole-farm system models.

**Methods**

The Trevenna demonstration site has a summer dominant rainfall and varies in elevation from 1068m to 1022m. The site has two different landscapes, the hills and the flats. The hill country is dominated by summer growing native species, interspersed with yearlong natives and naturalised cool season introduced species. The flats are dominated by perennial introduced species with a large percentage of legumes.

An initial EM38 survey and soil samples stratified the landscapes and paddocks for the demonstration. Additional subdivision occurred to block each landscape into three classes and three paddocks within each class. Botanical composition is examined each season within the two landscapes. Fertiliser has been applied at a rate of 20 kg/ha of Phosphorus, 25 kg/ha of Sulphur and 70kg/ha of Nitrogen to the flats that has assisted in delineating the differences between the 2 landscapes.

Stocking densities were determined using PRO Plus™ (McPhee *at al*. 2000). Fodder budgets indicated a stocking rate of 3.7 DSE/ha on the hills and 6.7 DSE/ha on the flats. Merino ewes were sourced from the UNE Merino research flock and were joined to Border Leicester rams in April 2010. Allocation of the pregnant ewes was randomised and lambing occurred in September 2010.

Monthly pasture (green herbage mass, legume percentage and quality) are recorded and regular animal production data (liveweight, condition score, fecundity, wool and carcass weights at slaughter) are being collected. In addition, pasture scans of the paddocks are made by the Crop Circle (Holland Scientific equipment model ACS210) to determine its correlation with measured herbage mass each month. Water holding capacity measurements and nitrous oxide is also being recorded from the site. The design of the demonstration site, including the replication, animals and pastures measurements are fully described in McPhee *et al*. 2010.

**Results and Discussion**

Data collected will be important in our understanding of whole-farm sheep production systems on the Northern Tablelands. Information will be used in models such as AusFarm and EcoMod, and the inventory models such as FarmGas and OVERSEER. At the end of the second year (2012), a detailed analysis will examine the differences between the two landscapes. A lifecycle analysis and economic study will also be conducted at the conclusion of the project.

On ground demonstration sites, such as Trevenna, are important for improving producers and researchers knowledge on methane production. Such sites will enable them to make decisions on methane mitigation options and to inform advisors and policy makers. It will also increase the understanding, awareness and adoption regarding methane emissions in farm carbon. The validation of farm system models will also be valuable in the appreciation of whole-farm systems and enable the testing of a broader range of mitigation option in the context of the Northern Tablelands environment.

**Acknowledgments**

The authors gratefully acknowledge the funding supported by Meat and Livestock Australia and the Australian Government's Climate Change Research Program. Assistance from students of the University of New England is also acknowledged along with the support from the University of New England staff.

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## 8. APEN abstract
## The Trevenna demonstration site

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### Abstract
The 'Trevenna' demonstration site is based at the University of New England, Armidale. The 36ha site gives livestock producers and researchers a practical insight into on-farm sheep production emissions from a sheep production enterprise. The site is one of four national sites across Australia and has been set up in collaboration with Meat and Livestock Australia and the Australian Government's Climate Change Research Program to demonstrate mitigation strategies for enteric emissions. It is a joint project between NSW Department of Primary Industries and the University of New England.

The demonstration site began in May 2010 and is evaluating methane emissions from two production systems. The replicated study over two years compares animal productivity and emissions of low fertility (i.e., hills) with high fertility (i.e., flats). Sheep are grazed on the hills and the flats at 3.7 and 6.7 DSE/ha, respectively. Extensive measurements of the pastures, soils and livestock are being made. Other measurements being recorded include soil water, nitrous oxide and soil carbon. Demonstration site measurements and experimental design are fully described in McPhee *et al.* 2010. The site has become an important source of information on greenhouse gases for producers, advisors, researchers, and students.

Analysis of the systems will be investigated using decision support tools, a lifecycle analysis and an economic study. This project enhances our knowledge of production systems on the Northern Tablelands and increases our understanding of methane emissions from ruminant livestock (sheep).

### Reference

McPhee MJ, Edwards C, Meckiff J, Baillie N, Schneider D, Arnott P, Cowie A, Savage D, Lamb D, Guppy C, McCorkell B and Hegarty R (2010). *Estimating on-farm methane emissions for sheep production on the Northern Tablelands: establishment of demonstration site.* AFBM Journal. 7:2 85-94

**Keywords:** Northern Tablelands, Extension opportunities

No 9 AFBM paper

# Estimating on-farm methane emissions for sheep production on the Northern Tablelands: establishment of demonstration site

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**Abstract:** A 36-hectare demonstration site at Armidale on the Northern Tablelands of New South Wales has been established to give livestock producers a practical insight into the magnitude of carbon fluxes, especially methane ($CH_4$), associated with crossbred lamb production. The site contains soil and topographical diversity typical of the region (pH 4.8–5.1 (1:5 $CaCl_2$); soil organic carbon 1.2–3.8 (%); cation exchange capacity 3–41 (meq/100g)). The replicated study over two years will compare animal productivity and emissions of low stocking rate enterprises on a low fertility (hill) section of the site (3.7 DSE/ha) with those of high soil fertility enterprises on the more fertile alluvial flats (6.7 DSE/ha). An EM38 soil map and seven soil samples were used to characterise the soil diversity within the two landscapes and to block each landscape into three classes (A, B, C), with three paddocks/class. Monthly pasture (green and dead DM availability) and regular production data (liveweight gain, fat score, fecundity, wool and lamb carcass weights at slaughter) will be collected. These measures will be used in decision support tools to estimate total on-farm $CH_4$ emissions, emission per unit product, and to conduct a life cycle analysis of the contrasting enterprises. It is intended to use the site as a regional reference point for effective integration of farm carbon, productivity and economic understandings.

**Keywords:** greenhouse gas, high fertility, low fertility, pasture production.

## Introduction

Agricultural emissions (methane ($CH_4$) and nitrous oxide ($N_2O$)) comprise 16% of Australia's total emissions, and livestock emissions (enteric fermentation and manure management) contribute 69% of agricultural emissions (Department of Climate Change and Energy Efficiency 2010). While there is no intention to directly include agricultural emissions in a future national emissions trading system, downstream penalisation on agricultural commodities is feasible and, more favourably, there may be opportunity for mitigation of agricultural emissions to provide a carbon offset market (Australian Farm Institute 2010).Therefore an increasing need exists to provide information to livestock producers including estimates of on-farm emissions and opportunities for on-farm emissions mitigation.

In collaboration with Meat and Livestock Australia and the Australian Government's Climate Change Research Program, the national "Reducing Livestock Emissions Program" has established four sites across Australia to demonstrate potential mitigation strategies for enteric emissions. These are: sites for beef and dairy emission mitigation in northern Queensland and Victoria respectively, and sites in Western Australia and in Armidale on the Northern Tablelands of New South Wales for sheep production. This paper discusses the establishment of the demonstration site for sheep production on the Northern Tablelands of New South Wales. It is anticipated that field days on the Northern Tablelands will equip producers with the knowledge, tools and strategies to manage and understand their on-farm sheep production emissions. The site will also provide training for undergraduate and postgraduate students in measurements of animal production, soil properties, and the use of whole-farm system models.

The objectives of this study are to:

1. Demonstrate to New England graziers the magnitude of sources and sinks of greenhouse gas emissions in a sheep grazing enterprise;
2. Demonstrate the contrasting production of greenhouse gases from low fertility and high fertility sheep grazing systems;
3. Demonstrate methods for predicting and measuring on-farm $CH_4$ production so producers can assess potential opportunities and liabilities in a carbon economy;
4. Develop an inventory of $CH_4$ production from grazing systems;

5. Train agricultural scientists in understanding farm carbon, pasture management and sheep growth and production.

This paper describes the establishment of the demonstration site and initial results.

## Methods

### *Plant, soil and topographical features of the site*

The 36-hectare demonstration site 'Trevenna', is located at the University of New England on the Northern Tablelands of New South Wales (latitude 30° 30′ S, and longitude 151° 40′ E). The Northern Tablelands has a summer-dominant rainfall and an elevation of 1000 plus metres. The existing pasture was dominated by summer growing natives such as red grass (*Bothriochloa macra*), yearlong natives (*Austrodanthonia spp.*, *Microlaena stipoides and Poa spp.)* and introduced cool season species such as Ryegrass (*Lolium spp.*), Broomes (*Bromus spp.*) and Paspalum (*Paspalum spp.*). There were also some legume species present such as Subterranean (*Trifolium subterraneum*) and White (*Trifolium repens*) clover.

The site has two distinct topographic landscapes (tougher hill country and fertile creek flats) that are being used to differentiate grazing systems into low and high fertility systems appropriate for the topography. An electromagnetic induction soil survey was conducted of the hills and flats on the 'Trevenna' on-farm emissions site. The derived apparent electrical conductivity ($eC_a$) maps were used to stratify the 'Trevenna' landscape into basic soil zones on the basis that spatial variability in $eC_a$ was a surrogated indicator of soil textural differences (Corwin and Lesch 2005). Soil samples to a depth of 100 mm were taken at seven marked sites varying in $eC_a$ (see Figure 1). All soil samples were analysed for $pH_{(Ca)}$, organic carbon, phosphorus, sulphur and exchangeable cations. Additional soil samples across all the paddocks were taken at the beginning of the demonstration and were air-dried and stored for future analysis. Fertiliser was applied to the flats during May 2010 at the rate of 20kg/ha of phosphorus and 25 kg/ha of sulphur, 70 kg/ha of nitrogen and 5 kg/ha of white clover seed.

Botanical composition, using the Botanal technique (Tothill et al. 1978) and herbage mass will be assessed each season in pre-located sites. In addition pasture samples investigating quantity and quality are taken at entry and exit of sheep from each paddock using the median quadrat technique as outlined in the appendix of the PROGRAZE manual (NSW Department of Primary Industries 2007). Scans of pasture quadrats are taken before the quadrat is cut to determine green and dead biomass using a Crop Circle (Holland Scientific equipment model ACS210). The image analysis data from the Crop Circle scans will be correlated with the actual total and green biomass to assist in calibrating the Crop Circle scans. Each paddock is also scanned along transects either north/south or east/west using Crop Circle equipment attached to a quad bike.

Water holding capacity measurements and $N_2O$ will also be measured during the trial. A soil density calibration to provide a measure of plant available water (PAW) capacity for the hills and the flats will be undertaken and the data (bulk density, saturated water capacity (mm/mm), drained upper limit (mm/mm) @ 1 bar pressure, lower limit (mm/mm) @ 15 bar pressure, clay and sand percentages) will be used as inputs into the whole-farm decision support systems.

### *Selection of appropriate long-term stocking densities*

Stocking density (DSE/ha) was determined using PRO Plus$^{TM}$ (McPhee et al. 2000), a whole-farm fodder budgeting decision support tool. Prior to commencement: the planning period, the area (ha) of each paddock, the estimated pasture growth rates (kg DM/ha/day) and intake (kg DM/ha) for each month and pasture biomass (kg DM/ha) at the beginning of the planning period, stock numbers and anticipated movement of stock between paddocks were entered into PRO Plus. Intake of supplementary feed (300g of grain and 300g of hay) and fodder quality were taken into consideration from September to mid-October. A fodder budget was calculated and used to modify stock numbers so that the livestock demand on pasture availability in early spring was met. The DSE/ha for individual paddocks on the two different landscapes and the overall DSE/ha for the hills and flats are reported.

### *Animal measurement and allocation*

Three hundred and nine Merino ewes from the UNE Merino research flock were group-mated to four Border Leicester rams over 38 days at a ratio of ~1 ram to 77 ewes. All ewes were pregnancy tested 75 days post-joining using ultrasound, weighed and condition scored by palpitation. From these, 168 ewes carrying single lambs were selected for the trial (starting LW = 40.91kg± 4.00kg) and allocated to experimental groups; 48 to graze on the hills split into three flocks (n=16 per plot) grazing across three paddocks to create a blocking effect across the hills, and 96 to graze on the flats split into three flocks (n=32 per plot) grazing across three paddocks, again to create a blocking effect across the flats, and 24 ewes were kept as replacements. The allocation of ewes to flocks used stratified randomisation based on liveweight. Ewes were moved to their initial allocated paddocks eight days prior to the commencement of lambing on September 10 2010. Staple and tensile strength and fibre diameter samples will be taken at shearing. Four ewes on the hills and four ewes on the flats have a GPS tracking device attached so that future research on the movement of ewes and lambs can be evaluated.

### *Estimating methane*

Methane will be estimated using the whole-farm decision support tools AusFarm (Horizon Agriculture 2010; Freer et al. 1997; Moore et al. 1997) and EcoMod (Johnson et al. 2003). Relevant data collected from the trial will be used as inputs to the models. FarmGas (FarmGas Calculator 2010) and OVERSEER (OVERSEER 2010;Wheeler et al. 2006) will also be used to compare the on-farm outputs.

### *Experimental design*

The experimental design is based on the plant soil and topographical features of the site; two landscapes (hills and flats) where each landscape is divided into three land classes (A, B, and C) each with three paddocks within each land class. In total 18 paddocks: nine on the hills and nine on the flats. Three flocks allocated to each of the landscapes with a rotation across the three land classes i.e. each flock rotationally grazes three allocated paddocks and hence rotationally grazes each land class (A, B, and C). The experimental design is not replicated within landscape, but the paddock subdivisions across the land classes are used as blocking effects to account for the variation across the landscapes. Replication of the experiment will occur across two years. Class and paddock were randomised before allocating flocks. Genstat version 13 (2010) was used to tabulate means and standard deviations and a two-way analysis of variance was performed to access differences between flocks.

## Results

### *Soil characteristics and available pasture*

Distribution of the two landscapes (hills, flats) and the within landscape classification (A, B, C) is shown in Figure 1. The profile of the apparent electrical conductivity (mS/m) of the soils is shown and the EM38 soil map assisted in determining the classifications (A, B, C). The chemical properties of soil samples taken at the start of the study are shown in Table 1. All assay analyses were conducted by a laboratory accredited under the National Association of Testing Authorities.

Soil pH was above critical levels of 4.7–4.8 in Ca and no lime was required on this site (see Table 1). The cation exchange capacity (CEC) reflected the soil texture closely, with sites located on the hills having basalt influence, higher clay contents and higher CEC. The more alluvial flat country had low CEC associated with its coarser soil texture. This is confirmed by the soil carbon concentrations being <1% lower on the flats where the coarser texture limits accumulation of carbon sequestration. Soil P was uniformly high (Colwell >35 mg/kg) across the demonstration site, posing no limitation to the establishment and persistence of legume pastures. The Phosphorus Buffer Index (PBI) of both hill and flat country indicates that starter basal P applications will remain highly available throughout the life of the demonstration. In contrast, the low CEC and lighter textured soils have sulphur levels ($KCl_{40}$-S) < 8 mg/kg and hence sulphur application (25kg/ha) was essential to maintain persistent legumes in the swards.

Figure 2 illustrates the Normalised Difference Vegetation Index (NDVI). The quantity of pasture available is represented as an NDVI in all of the paddocks for the hills and flats and paddocks HA2, HB3, HC3, FA3, FB3, and FC3 illustrate the lower quantities of pasture available after ewes and lambs have grazed on the paddocks for the first 39 days of the trial.

### *Selection of long-term stocking densities*

The simulated results, at the end of the month from June 2010 to March 2011, of pasture availability (kg DM/ha) for ewes grazing in paddocks HA2 and FA3 on the hills and flats, respectively, are shown in Figures 3 and 4. The paddock stocking densities were 5.4 and 9.3 DSE/ha for HA2 and FA3, respectively and the landscape averages on 18 ha were 3.7 and 6.7 DSE/ha, for hills and flats, respectively.

### *Animals*

The live weights and condition scores of six flocks are shown in Table 1. There was no difference in ewe liveweight or condition score at the start of the study ($P>0.05$). Since all ewes entered the trial carrying a single lamb, no testing of treatment effects on the number of lambs has been made in year 1.

## Discussion

The establishment of the 'Trevenna' UNE on-farm methane emissions for sheep production demonstration site has been assisted through the use of EM38 maps as illustrated in Figure 1. The EM38 soil map (Figure 1) clearly defines the two different landscapes (hills and flats) and the apparent electrical conductivity (Figure 1) assisted in ascertaining where the demarcations were for the different land classes (A, B, C) within the landscapes. The EM38 soil map also assisted in determining the location of fencing for the paddocks. The Cicerone project, a producer-led research/adoption group, conducted on the Northern Tablelands of New South Wales also used EM38 mapping for the layout of their paddocks after optimising the distribution of land according to soil, fertiliser and topography (Scott 2003).

The fodder budgets (Figures 3 and 4) were valuable for determining the stocking rate densities. The 3.7 and 6.7 DSE/ha on the hills and flats respectively are close to the average DSE/ha for the region. Pasture availability at lambing was a critical window and hence supplementary feeding during this period assisted in maintaining the ewes with a condition score that ranged from 2 to 4 across the 144 ewes.

Measuring the quantity and quality of pastures is an extremely important component of this project. Determining the amount of green and dead feed available to livestock is essential for estimating on-farm $CH_4$ emissions. Figure 2 illustrates the changes in pasture availability as indicated by the NDVI. Actual green and dead biomass (kg DM/ha) will be used to calibrate the NDVI values shown in Figure 2.

The pasture biomass, and data collected during this project (e.g., liveweight, fleece weight, rainfall and water capacity) will be used to simulate sheep production on the Northern Tablelands. The decision support tools AusFarm and EcoMod and the inventory models FarmGas and OVERSEER will be used to estimate $CH_4$. At the end of the second year a detailed analysis will be conducted to determine the differences between landscapes of $CH_4$ produced (g)/kg of sheep meat and wool produced. A simulation study using 50 years of weather data will be conducted to analyse long-range forecasts of climate change. A life-cycle analysis will also be conducted at the conclusion of the project.

The results of estimating $CH_4$ from the decision support tools and the inventory models need to be treated with caution. Baseline estimates of $CH_4$ using open-path Fourier-transform infrared spectrometer technology and measuring $CH_4$ production in chambers will assist in interpreting the results from the decision support tools. Further research is required in building mathematical models to improve the prediction of $CH_4$ production.

## Conclusions

The information gathered from this type of demonstration will be important in the decisions made by regional graziers, advisers and policy developers. Producers will have on–ground local and relevant information that will help in long-term understanding of the principles and practicalities of their farm systems. The analyses from the different models will be useful in estimating $CH_4$, and carbon cycling on a relevant albeit, small-scale demonstration site. By using multiple farm system models, greater (or lesser) confidence in the estimates can be conveyed to producers, advisers and policy makers. An increased understanding of the usefulness of models and their generated outputs will be helpful to those using the models, as well as providing a greater knowledge of the input drivers.

## Acknowledgements

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Table 1. Results from soil sample analysis taken across seven sites at the Trevenna on-farm methane emissions demonstration site. Sampling sites are identified on the site map provided in Figure 1.

| **Soil parameter** | **Sampling site** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| pH (1:5 CaCl2) | 5.4 | 5.2 | 5.6 | 4.7 | 4.9 | 4.8 | 5.1 |
| Organic Carbon (%) | 3.8 | 3.7 | 2.6 | 1.3 | 2.0 | 2.9 | 1.2 |
| SulphateSulphur (KCl40) (mg/kg) | 6.2 | 5.5 | 2.8 | 5.1 | 4.1 | 7.8 | 2.6 |
| Phosphorus (Colwell) (mg/kg) | 85 | 51 | 100 | 71 | 69 | 91 | 130 |
| Phosphorus Buffer Index | 190 | 150 | 200 | 61 | 53 | 140 | 35 |
| Cation Exch. Cap. (CEC) (meq/100g) | 29.4 | 13.7 | 41.0 | 4.61 | 8.56 | 11.6 | 3.11 |

Table 2. Live weights (LW) and condition scores (CS) of pregnant ewes with single lambs for each flock

| **Flock** | **No** | **LW (kg)** | **CS** |
|---|---|---|---|
| 1 | 16 | 40.35 | 2.88 |
| | | (3.29) | (0.50) |
| 2 | 16 | 40.89 | 2.91 |
| | | (4.00) | (0.55) |
| 3 | 16 | 40.42 | 2.97 |
| | | (4.11) | (0.50) |
| 4 | 32 | 40.90 | 2.91 |
| | | (4.16) | (0.50) |
| 5 | 32 | 41.13 | 2.92 |
| | | (3.69) | (0.49) |
| 6 | 32 | 40.82 | 2.95 |
| | | (4.11) | (0.53) |

Figure 1. Paddock layout and size of paddocks for the hills (H) (low fertility) and flats (F) (high fertility) landscape and their classes (A,B, and C) within the landscapes at the Trevenna on-farm methane emissions demonstration site, Armidale, the soil GPS satellite classification and sample sites

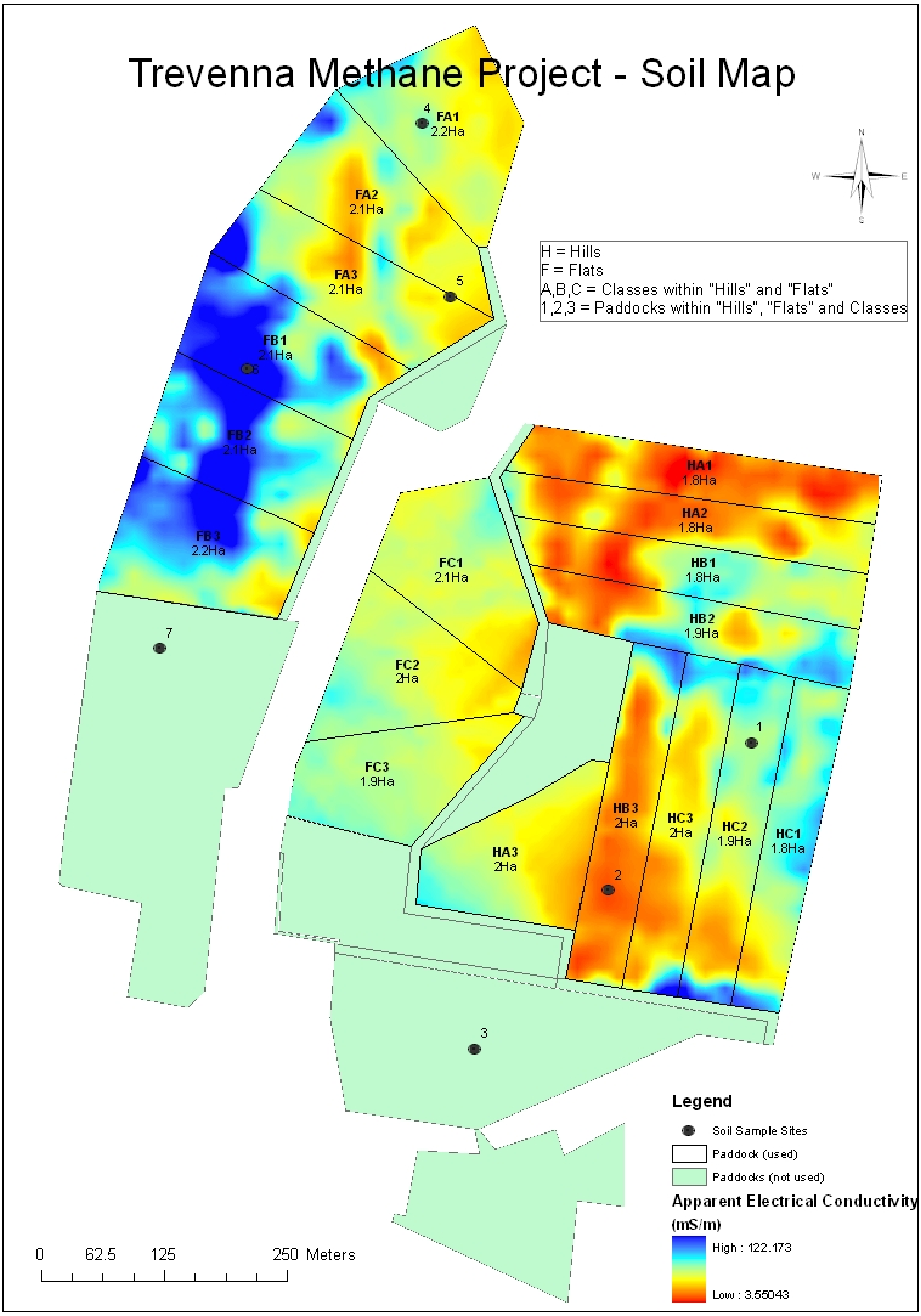

Figure 2. Normalized Difference Vegetation Index (NDVI) of Trevenna paddocks taken on the 18th October 2010 for the hills (H) (low fertility) and flats (F) (high fertility) landscape and their classes (A, B, and C) within the landscapes at the Trevenna on-farm methane emissions demonstration site, Armidale
Note: the lower the NDVI index the lower the pasture biomass available

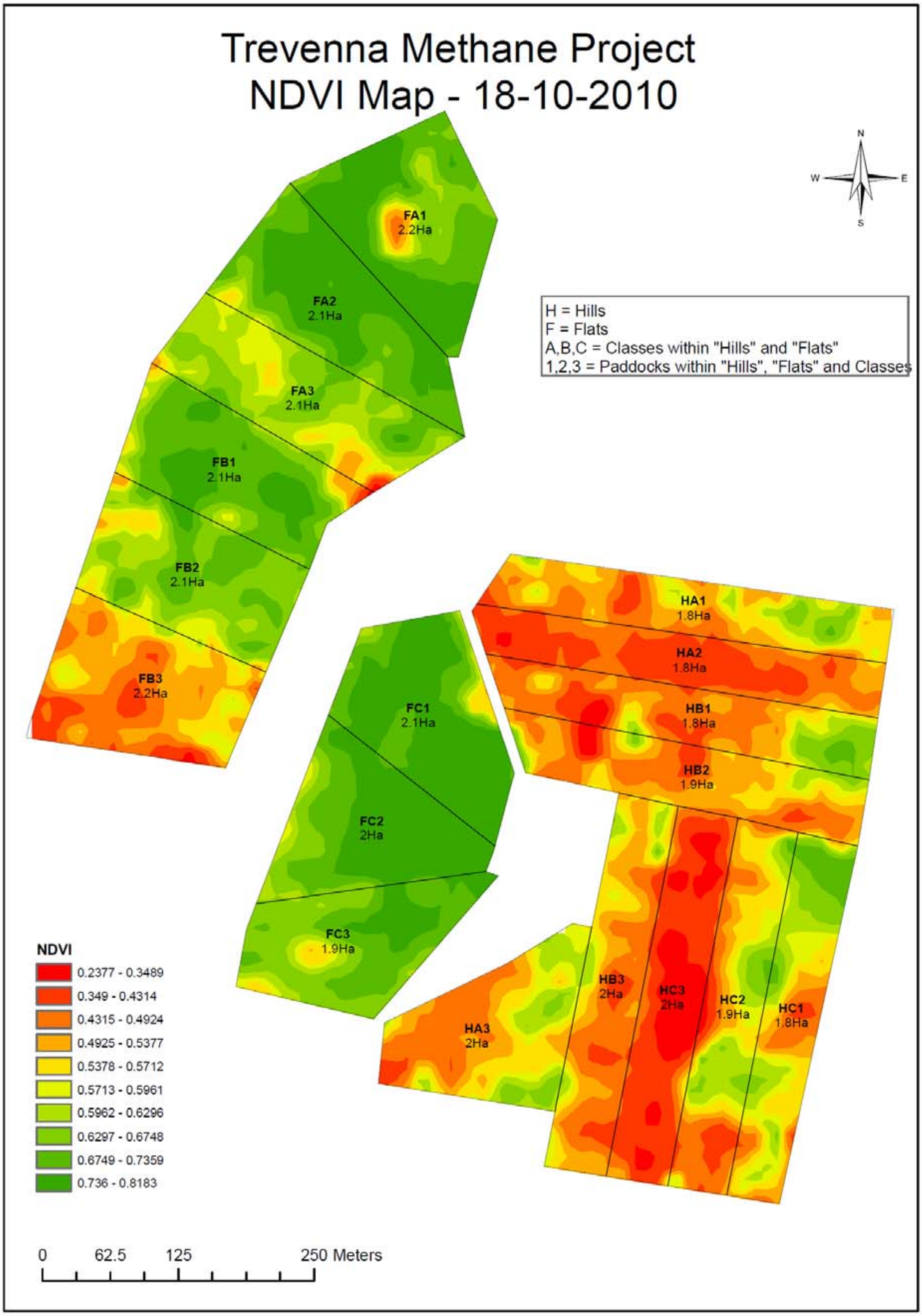

Figure 3. Pasture growth rate (kg DM/ha/day), intake (kg DM/ha/day) and green pasture biomass available (kg DM/ha) for each month (value at end of month; values in parenthesis are days ewes grazed in paddock) on the hills (H) (low fertility) landscape for class A paddock 2

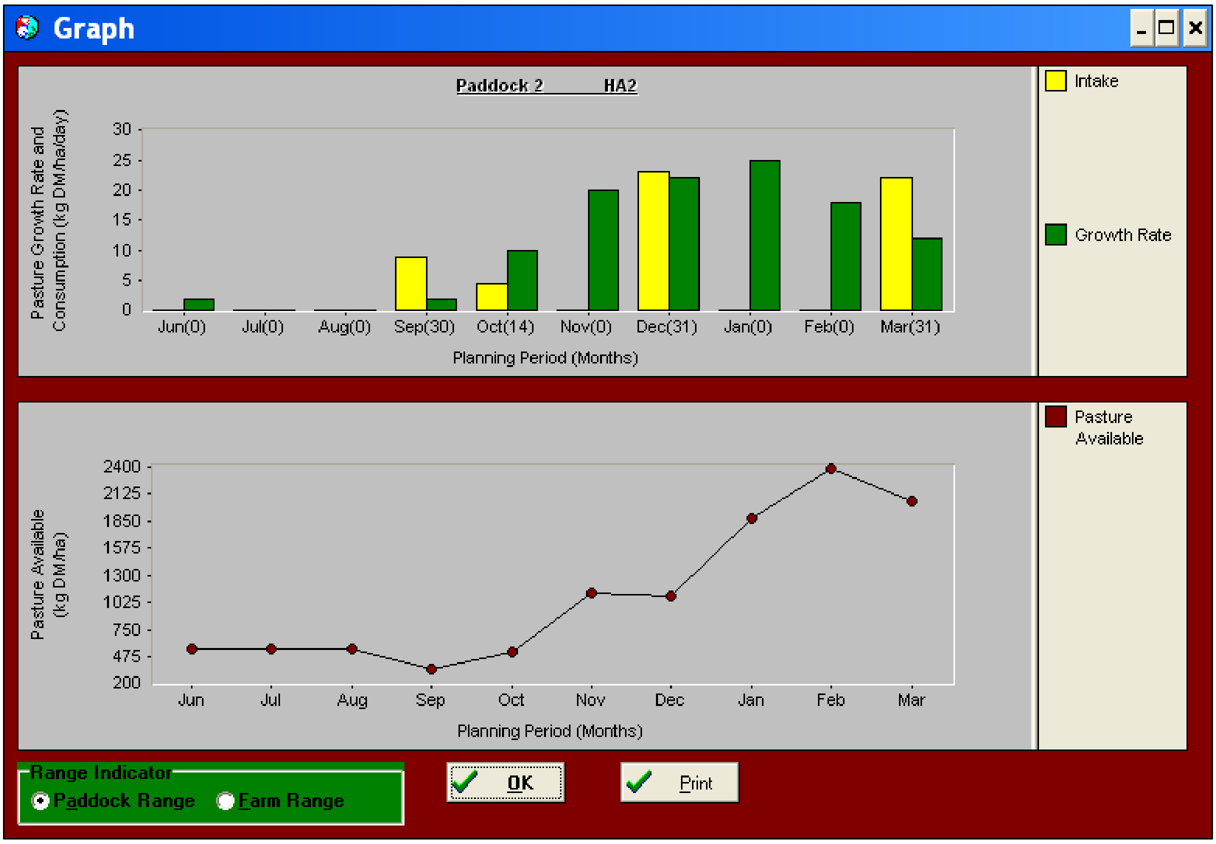

Figure 4. Pasture growth rate (kg DM/ha/day), intake (kg DM/ha/day) and green pasture biomass available (kg DM/ha) for each month (value at end of month; values in parenthesis are days ewes grazed in paddock) on the flats (F) (high fertility) landscape for class A paddock 3

10.. Summary of media releases

- Media release - Producers learn about methane at demonstration site 2nd March 2011 http://www.dpi.nsw.gov.au/aboutus/news/recent-news/agriculture-news-releases/producers-to-learn-about-methane
- Flyer – Landcare Adventure, sent to local producers, local agribusiness and retail stores
- Local papers – the country leader, the Armidale express
- ABC radio - announcing the field day
- ABC radio – interview on the 1st April 2011
- Media release – I&I NSW Armidale sheep flock part of real life study 1st April 2011 http://www.dpi.nsw.gov.au/aboutus/news/recent-news/agriculture-news-releases/sheep-flock-part-of-real-life-study

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McPhee MJ, Edwards C, Meckiff J, Ballie N, Schneider D, Arnott P, Cowie A, Savage D, Lamb D, Guppy C, McCorkell B and Hegarty R (2010). Estimating on-farm methane emissions for sheep production on the Northern Tablelands: establishment of demonstration site. AFBM Journal. 7:2 85-94

## Conference and Symposium Papers

Edwards C, McPhee MJ, Meckiff, Ballie N, Schneider D, Guppy C, Cowie A and Hegarty R (2011). The Trevenna methane demonstration site: soils component. Abstract submitted to the NSW DPI Climate and Soils Symposium, Cumberland State Forest, West Pennant Hills, NSW 21-22 September 2011

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