**Baseline Phase Reporting**
**January to June 2012**

**Proceedings of the First**
**Knowledge Exchange Workshop**
**Birmingham 23rd May 2012**

# Project AC0114

# Data Synthesis, Management and Modelling

## Agricultural Greenhouse Gas Inventory Research Platform


**Contents**

## 1. Introduction

The Agricultural Greenhouse Gas Platform held a Knowledge Exchange workshop on the 23rd May 2012 at the Best Western Westley Hotel, Birmingham, to provide an overview of the experimental approaches within the Platform and an opportunity for stakeholders to provide feedback on on-going work to develop the improved inventory methodology.

The workshop was organised in three phases. The first phase consisted of 'Scene Setting' and consisted of an introduction to the Agricultural Greenhouse Gas Platform projects by Luke Spadavecchia (Defra) followed by presentations from Dave Chadwick (Rothamsted Research – North Wyke) and Jon Moorby (IBERS) who provided an overview of experimental approaches within the Platform (Projects AC0116 and AC0115). During the second phase, entitled 'Early Results', Sarah Buckingham (SAC) and Steven Morrison (AFBI) presented on the findings from the literature reviews that are being carried out within Work Package 2 of the Data Management and Modelling project (Project AC0114). The third phase consisted of presentations by Tom Misselbrook and Adrian Williams on the development of the revised inventory structure and calculation methodology, and the use of government and industry data to track changes in farm practices. The third phase was used as an introduction to a workshop activity to scope farm practice questions suitable for inclusion within existing and new national surveys for improving our understanding of baseline farm practices and for tracking change. This involved break-out groups evaluating known data gaps and proposed survey questions for each of the agricultural sectors.

The workshop was also an opportunity to maintain positive working relationships between industry representatives and the members of the AC0114 team. The workshop planning was led by Laurence Smith (WP 6) with considerable support from Tom Misselbrook (WP 1), Adrian Williams (WP 3) and Steven Anthony (WP 6). The workshop was attended by 47 delegates from industry and government (see Workshop Note 3 Attendance). The Devolved Administrations were represented by members of the Scottish Government, Welsh Government and the Department of Agriculture and Rural Development in Northern Ireland (DARDNI).

## 2. Presentation Abstracts

### 2.1 Luke Spadavecchia – Defra

**Agricultural GHG R&D Platform - Background, Motivation and Overview**

The opening presentation was given by Luke Spadavecchia from Defra (Sustainable and Competitive Farming Systems Programme) and provided an introduction to the background, motivation and an overview of the GHG Platform project.

Historically the requirement to compile an inventory has been driven by the international reporting requirements of the UNFCC Kytoto Protocol that entered into force in 2005. An annual estimate of greenhouse gas emissions from UK agriculture is compiled by North Wyke (Rothamsted Research) on behalf of Defra and submitted to DECC for inclusion in the official National Inventory Report. The inventory data is carefully checked and reviewed by an independent central review team on behalf of

the UNFCCC to ensure it complies with the IPCC good practice guidance on inventory compilation.

Agriculture presently contributes *c*. 9% of total UK GHG emissions. The key agricultural sources are livestock enteric methane emissions and nitrous oxide emissions from soils. All inventory emissions are hind-cast from 1990 as the base year for the Kyoto protocol, and the UK has been successful in reducing reported emissions from agriculture since 1990. However, this has largely been due to a reduction in the size of the agricultural sector in this period, including reductions in livestock numbers and notably fertiliser inputs to grassland. There have clearly also been improvements in farm efficiency in this period, but the inventory emissions calculations are driven by farm inputs and do not adequately represent these changes. Economic projections predict further contractions in some sectors and growth in others (notably dairy and non-cattle), and a slight increase in agricultural energy use by 2020. The net result of the general contraction of the UK agricultural sector is predicted to be a further reduction in emissions by 2020. However, current DEFRA policy is to increase UK production which would result in increasing emissions under the current inventory model because it is relatively insensitive to efficiency gains and only reflects the number of livestock and amount of fertiliser applied at the national scale. It is therefore critical that we develop an improved inventory that is capable of reflecting the effects of the improvements in efficiency.

There is also significant uncertainty attached to the inventory emission calculations. Uncertainty is a fact of life in the biological sciences, since we are dealing with highly heterogeneous systems. The main uncertainty is related to soil emissions of nitrous oxide, and the Platform aims to reduce these uncertainties as much as possible. The large uncertainties relate to the current inventory structure, which applies across the whole UK with little disaggregation by sector. There is significant structure to this uncertainty by location and sector (which are linked, particularly when considering the DAs), and through time. The sector is aggregated into simple units for reporting, and does not take account of differences between farm sectors or spatial patterns of soil and climate. Investment in research on the inventory will increase our understanding of these structured variations and reduce the overall uncertainty in the inventory.

In summary, the current inventory methodology is a relatively blunt tool that uses standard emission factors not specific to UK farm systems; is unable to capture the effects of mitigation measures; is unable to represent differences across farming sectors, practices or soil types; has limited spatial and temporal resolution; and has significant uncertainties on many emission estimates.

A development since the Kyoto Protocol has been the Climate Change Act (2008) under which the UK is committed to reducing GHG emissions by 80% by 2050. All sectors must play their part in the reduction. As the energy and transport sectors de-carbonise, agriculture will contribute a greater proportion of total UK emissions and it will therefore become more important to track effective mitigation. In response to the Climate Change Act the agricultural industry have drawn up an Action Plan comprising priorities for on-farm action. Defra analysis of the Action Plan indicates that if the plan is well implemented there should be significant reductions in GHG emissions from agriculture. There will also be benefits for other pollutants and potentially also for biodiversity. Defra has commissioned additional research to understand the wider environmental benefits of the Action Plan and to confirm the economic benefits that should result from more efficient farming.

In response to these changing requirements, and the need to reflect the effects of changes in farm practices in the emission calculations, Defra and the Devolved Administrations have funded a £12 Million programme of research to deliver an improved Agricultural GHG Inventory, consisting of four linked projects. Projects AC0115 and AC0116 will deliver measurements of emissions of methane and nitrous oxide from representative UK farm systems and environments to improve the fundamental emission calculations in the inventory, and project AC0114 will deliver the farm management and environmental data necessary to build the inventory and act upon any changes in farm practices. The AC0114 project also has a knowledge exchange function to disseminate findings to industry and other stakeholders. The outputs from these projects will feed into the ongoing AC0112 inventory delivery project. The programme of work began in November 2010 and measurements of methane and nitrous oxide emissions from UK experimental sites are well under-way. Significant work has also been carried out to collate data on UK farm management affecting emissions and develop the inventory model.

This workshop is an opportunity to view early outputs from the programme and contribute to the development of the improved inventory. Our intention is that the improved inventory will ensure that a profitable and growing industry with more efficient farming practices is accurately reflected in emissions reporting, and break the simplistic relationship between the scale of agricultural activity and emissions by adequately accounting for improved quality of management.

### 2.2 David Chadwick – Rothamsted Research, North Wyke

### Experimental Approaches Being Used in Project AC0116: Nitrous Oxide

David Chadwick, lead of the AC0116 Project, provided an overview of the experiments being carried out to provide new measurements of nitrous oxide emission factors from representative UK environments.

Project AC0116 (the Inve$N_2$Ory project) aims to provide measured and modelled nitrous oxide ($N_2O$) emission factors (EFs) from which a Tier 2 based approach to reporting the national agricultural inventory can be developed. This reporting tool should better reflect the range of soil types, climates and management of nitrogen (N) sources from UK farming systems and enable specific mitigation practices to be reflected. The extent of the experimental work and requirement for modelling and verification mean that this project requires an interdisciplinary research consortium comprising 8 separate organisations.

The project has already confirmed the geo-climatic positions for 9 key experimental field sites (5 grassland and 4 arable) throughout the UK, covering a range of soil and climatic conditions. IPCC compliant EFs are being quantified at each of these sites (which means we need to provide 12 months of measurements following addition of an N source to the soil, and a zero-N control treatment must be included in the experiments). Research teams have developed standard experimental protocols for plot layout and experimental design, chamber deployment, soil sampling etc. for all sites. The key N sources that are being applied are; dung and urine, a range of different manure types (and application methods), and different rates of ammonium nitrate fertiliser and a comparison with urea fertiliser (at one rate). Measurements of $N_2O$ fluxes are being made from different application/deposition timings, to provide EFs appropriate to the season of application/deposition. Specific mitigation that is being tested includes the use of the nitrification inhibitor, DCD, and using more frequent but smaller split doses of ammonium nitrate.

Static chambers are being used to quantify $N_2O$ fluxes at the field sites, and the frequency of sampling has been designed to capture the total annual $N_2O$ flux from an understanding of the drivers controlling $N_2O$ production, generating >30 samples per year per chamber. An autochamber at each site is generating $N_2O$ fluxes from one plot several times per day (4-6), so we can compare the fluxes with those from the static chambers and estimate the uncertainty associated with the single daily measurement point from the static chambers. The autochamber will also provide indications of the fluxes on days when no static chamber measurements are made.

Ammonia emission measurements are also being made from the manure experiments, and nitrate leaching is being estimated at the sites with permeable soils using porous cups. These additional measurements provide evidence associated with indirect $N_2O$ losses, and will help us to interpret data and modelling outputs through a better understanding of the fate of applied N. A laboratory incubation experiment is being conducted to provide a greater understanding of the controls affecting the efficacy of the nitrification inhibitor, DCD, on reducing rates of nitrification in the soils from the 9 experimental sites, whilst work in the Defra Demonstration Test Catchments (DTCs) is quantifying indirect $N_2O$ losses associated with dissolved $N_2O$ in drainage waters.

It is not possible to measure new EFs from every combination of N source, soil type and climate combination. Hence, the project is using two models, DNDC and DayCent, to help interpolate between measured EFs. These models are also important in gap filling (between sampling points), estimation of the uncertainty in $N_2O$ fluxes as a result of different soil and climatic conditions, and in testing the ability of proxies to estimate fluxes. Mitigation modelling is also planned.

A verification workpackage is determining the uncertainties in scaling up from, e.g. plot scale emissions to the field scale, and the temporal scaling from one measurement per day to 4-6 measurements per day, using state-of-the-art analytical equipment in field campaigns at some of the 9 experimental sites. Verification of the current and revised $N_2O$ emissions inventory is also being studied at the regional scale, where inverse modelling of atmospheric $N_2O$ concentrations from tall towers will be compared with bottom-up EF-based emissions from the agricultural footprint around the towers.

Finally, the project will also provide new information on N excretion in dung and urine collected from livestock being used in the methane trials (project AC0115), thus linking diet to N excretion. Uniquely, a new collaboration with New Zealand research organisation will allow us to quantification N loadings via urine events from grazing cattle, and generate ammonia EFs from some of the AC0115 trials.

It is via these interlinked project activities and careful integration with project AC0114 (the Synthesis project), that we will deliver robust $N_2O$ EFs that better reflect UK conditions and N management, thus enabling a Tier 2 based inventory tool to be delivered.

### 2.3 Jon Moorby – IBERS

**Experimental Approaches Being Used in Project AC0115: Methane**

Jon Moorby, lead of the AC0115 Project, provided an overview of the experiments being carried out to provide new measurements of methane emission factors from representative UK farm systems.

Defra project AC0115 aims to generate new methane emission factors for UK ruminant livestock and their manures over the course of its lifetime. It involves a number of research organisations throughout the UK, representing all countries of the UK. A number of methodologies are being used by the project partners to measure methane emissions from both housed and free-ranging cattle and sheep.

The key method for measuring methane emissions from housed animals is the use of the methane chamber, which is used to determine the release of enteric methane (i.e. of gut origin) from animals by measuring the difference in methane concentrations of ambient air and chamber exhaust air, and multiplying by the rate of air flow out of the chamber. Project partners are using a number of chamber designs that all do essentially the same thing, and a critical part of the project is an inter-comparison of the difference chamber designs to ensure that all results obtained this way are directly comparable.

Animals housed in chambers are being fed well-characterised diets and producing manures that can be collected. Some of these manures are being investigated in more detail to determine the potential methane emissions from them. Incubation of the manures for a prolonged period with a standard inoculant of microbes provides information on the release of methane from those manures. Analysis of the same manures by near-infrared (NIR) spectroscopy will enable a calibration to be created that may enable much more rapid estimation of the methane emission potential of other manures.

For animals maintained at grazing, the sulphur hexafluoride (SF6) method is being used by many of the project partners. This method relies on the use of a small tube of SF6 that is placed in the animal's stomach and which releases the inert gas in minute quantities at a known constant rate. By capturing gases released from the animal's mouth and nose, and by measuring the ratio of methane and SF6 collected over a 24 hour period, the rate of release of methane can be calculated from free-ranging animals.

The project is also investigating novel methods of estimating methane emissions from livestock. Online monitoring equipment installed in the feed hoppers of milking machines for dairy cows and beef cattle feeders enable methane emissions to be measured while animals are feeding. Emissions at milking and during feeding are being compared and calibrated with total daily emissions measured using chambers. By the end of the project, a new set of UK-specific methane emission factors will have been generated from cattle and sheep, covering a range of breeds, physiological stages, feeds, and geographical locations that will be used in the new inventory structure under development in project AC0114.

### 2.4 Sarah Buckingham – SAC

### Preliminary Results from a Literature Review of Nitrous Oxide Emission Factors (AC0114)

A tier 1 emission factor (EF) of 1.25% IPCC (1997) is presently used to calculate national anthropogenic emissions of $N_2O$ from the use of fertilizers and animal manures. Uncertainties in EFs have been measured due to differences in environment, crops and land management; these are not included in the current Tier 1 approach. The aim of projects AC0114 and AC0116 is to develop a reporting tool that better reflects the UK environment and agricultural systems through an

increased understanding of the processes and factors controlling agricultural $N_2O$ emissions. The project will collate data to place the UK in a wider context and assess inventory uncertainties.

*Nitrous oxide and methane emissions from non-UK manure storage experiments:*

A systematic literature review approach has been used to compile experimental data. This consisted of 9 searches yielding a total of 516 publications. Using inclusion/exclusion criteria developed in the literature review strategy, publications were screened for applicability. This section is in-progress with data currently being extracted from 78 publications.

*Collation and review of non-UK $N_2O$ emissions and EFs:*

Experimental data for $N_2O$ emissions, EFs and auxiliary parameters were extracted from 63 publications deemed suitable to project objectives through a systematic screening of 951 publications. Excluded publications were those that comprised no field data and/or not relevant to UK (in terms of climate or agricultural system/management). From 63 publications, there were 6 publications comprising < 1 month experimental period and 47 publications covering > 1 months monitoring period. There were various issues with the ability to compare these studies succinctly due to the range of methods used, approaches taken, missing values/lack of information provided, various styles of managed agricultural systems and an array of environmental conditions.

Meta-analysis was conducted utilizing data from six publications consisting of 41 entries. The small sample size is due to the lack of publications that provide data for the key input parameters in meta-analysis (the mean daily $N_2O$ flux - or ability to calculate daily flux from a full year of measurements, standard errors of the $N_2O$ flux and sample size/number of replications for both fertilized and control treatments). Emission factors from non-UK sites ranged -2.5% to 3.8%. Within the subsample extracted for meta-analysis the widest variation of EFs reported was for organic soil plots in Finland. However this site is the only organic soil included in the dataset and so there is little evidence to confirm that this is a true representation of EFs from organic soils. Results show a positive (> 0%), significant overall effect size of fertilizer application for both EFs and $N_2O$ emissions from treatment versus control plots.

Meta-regression of N application to the soil and the effect size were not significant ($p=0.08$), although when removing 4 entries that differed to other entries (small N application as a control and different crop types being used as control and treatment plots) the slope became slightly significant, a slope of 0.00158 at $p=0.049$. This indicates that the effect size of treatment versus control applications may increase with increasing N application, although more detailed data would be required to confirm. Publication bias is also being considered through meta-analysis software through a selection of techniques. REML analysis is also being conducted on the full dataset of $N_2O$ emissions, EFs and auxiliary data to assess connections between multiple parameters.

*UK Historic Dataset*

UK historic data gathered will be used to improve the characterisation of probability distribution function for EFs for: Climate /soils, fertiliser / manure and in assessing the uncertainty analysis of the inventory. AC0116 experiments and other relevant programmes currently occurring will be added to the database. Preliminary results

show there to be variation in the data (fertilizer EFs) spatially and temporally. In general emission factors vary around 1% with the exception of one site (Debathe), which has larger temporal variation in EFs compared to other sites. For slurry treatments the data indicates to application methods being an influential parameter with higher EFs originating from plots using the trailing hose method (compared to trailing shoe and broadcast methods)

In general the compiled datasets indicate spatial and temporal variation in EFs for both non-UK and UK studies for both fertilizer and slurry applications. Initial results also indicate that slurry application method is a contributing factor to variation seen. Combined datasets demonstrate the advantages and justify the importance of AC0116 experimental programme that addresses gaps in the inventory, provides measurements for scenarios that are understudied and yield a comprehensive dataset of annual field measurements for N2O flux/EF over a range of scenarios derived from a standardised protocol that are fully IPCC compliant.

### 2.5 Steven Morrison – AFBI

**Preliminary Results from a Literature Review of Enteric Methane Emission Factors (AC0114)**

Methane ($CH_4$) is a potent greenhouse gas (GHG) which has a global warming potential 25 times greater than carbon dioxide (Sejian et al., 2011). Enteric fermentation is the main source of $CH_4$ emissions from agriculture with baseline emissions of $CH_4$ presently estimated using methodology developed by the IPCC where livestock numbers are multiplied by default emission factors.

Development of an improved agricultural greenhouse gas inventory is needed to assist in complying with the demanding reduction targets set by the UK Climate Change Act for the UK GHG emissions. The current inventory no longer meets the requirements of international reporting with limited capacity to include country and practice specific emission factors that accurately reflect the adoption of mitigation practices by the agricultural industry.

The aims of this review were to 1) quantify the appropriateness of current IPCC methodology to calculate $CH_4$ emissions and 2) provide a review of published methane emissions from a range of livestock types and production systems relevant to UK agriculture.

A systematic literature review was conducted using a range of search tools and terms. In total over 200 papers were identified with data extracted into a comprehensive spreadsheet. Strict accept/reject criteria were then applied to each paper/treatment to ensure data was relevant to the UK and the methodology was robust. Almost 50% of the papers originally identified were rejected. Data recorded in the spreadsheet included background information of the source of the reference (journal, location, year published), diet/design (indoor/outdoor, diet, treatments, animal age and number per treatment, forage type), animal performance (intake measurement technique, DM intake, GE intake, live weight, milk yield) and methane production ($CH_4$ measurement technique, $CH_4$ production, $CH_4$ energy output). Treatments reported in the published literature were categorised into livestock groups and diet type e.g. dairy cow indoor diets.

The quantity and quality of data accepted for inclusion in the review varied by livestock group and diet type but in general few studies reported $CH_4$ emissions

under grazing conditions with limited reporting of gross energy intakes in many studies. Tier 2 emission factors for each livestock class are based on the proportion of gross energy intake lost as methane with IPCC recommendations of 6.5 % ±1 % for cattle (3.5% for grain based beef finishing diets), sheep and 4.5 % ±1 % for lambs. In the current review the proportion of energy intake lost as methane energy for all livestock types were in line with the IPCC recommendations however the range in values was much greater that the ±1 %. Extracted data will be further examined to ascertain if any pattern for high/low emissions relative to energy intake can be established. The outcomes of this review will help and refine work being conducted under AC0115.

### 2.6 Tom Misselbrook – Rothamsted Research, North Wyke

### Progress Towards a Revised Inventory Structure (AC0114)

A more detailed structure and methodology are required for the UK GHG inventory in order to accurately reflect emissions according to country-specific management practices and soil/climate effects, to capture uptake of mitigation practices and to better monitor emission trends against national and international targets. By providing a detailed proposal for the inventory structure and calculation methodology, we are dictating the required structures for the emission factors, activity data and other parameters, which will inform all other aspects of the GHG Platform work.

Emissions of methane ($CH_4$) and nitrous oxide ($N_2O$) will be calculated for 3 key sources: enteric fermentation ($CH_4$), manure management ($CH_4$ and $N_2O$) and soils ($N_2O$). At the simplest level, a model 'engine' containing the appropriate algorithms to estimate emissions from these sources will combine activity data (e.g. livestock numbers, fertiliser use, management practices) with emission factors to provide output reports summarising emissions according to the format required for UNFCCC reporting, summarising by Devolved Administration and by Agricultural sector (at UK and DA level).

The model input data and calculations will be structured by agricultural sector (i.e. Dairy, Beef, Sheep, Pig, Poultry, Other livestock, Arable, Horticulture). Further within-sector disaggregation will be made where standard production systems can be defined that are associated with systematic differences in activity data parameters. For example, the Sheep sector may be structured as containing Hill, Upland and Lowland breeding flocks, which can be associated with particular breed types (and live weights) and dietary characteristics. Data will also be disaggregated to an appropriate spatial (DA, regional) and temporal (seasonal, monthly) resolution to reflect associated differences in practices, parameters and/or emission factors. This detailed structure is designed to provide an accurate, bottom-up description of each sector for calculation of emissions and is not designed to be used for within-sector systems comparisons and does not provide a full life-cycle analysis for a given system.

The IPCC 2006 Guidelines will form the basis of the calculation methodology, as compared to the currently used IPCC 1996 Guidelines and 2000 Good Practice Guidance. For all key source categories, we will be moving to a higher Tier methodology, i.e. a more detailed, country-specific approach. For enteric $CH_4$ emissions for cattle and sheep, UK-derived energy balance equations (e.g. as in the 'Feed into Milk' publication) will be used in preference to the IPCC US-derived equations. This will require detailed production parameters including live weight, milk yields, growth rates, slaughter weights and diet composition. These data will also be

used to derive N excretion estimates specific to livestock type and production system. For manure management, detailed country-specific data on manure management practices and manure composition will be combined with country-specific estimates of CH4 conversion factors to derive $CH_4$ emissions. Nitrous oxide emissions will be estimated as part of a Tier 3 N-flow approach, modelling all N losses and transformations throughout the manure management continuum. For $N_2O$ emissions from soils, the proposed calculation methodology will take account of the form of soil N amendment (fertiliser, slurry, FYM, dung, urine) and the soil/climatic zone, while representing other specific management practices as appropriate.

### 2.7 Adrian Williams – Cranfield University

**Review of Government Surveys and Industry Data to Track Change (AC0114)**

Adrian Williams presented on the use of Government and industry data to keep track of changes within an improved inventory, drawing on the work that has been carried out within work-package 3 of AC0114 (i.e. a critical appraisal of industry and government data for use within the inventory).

Adrian highlighted that most greenhouse gas (GHG) emissions (GHGE) are calculated as:

$$GHGE = EF \times AV \qquad \text{(EQ. 1)}$$

Where EF is the Emission Factor and AV is an Activity Value (which may be composed of several related values). Activity data values include: animal numbers, types, ages, feed composition, housing & manure types, crop areas, crop types and location (soil-climate), N applications to land (fertiliser & manures), time animals spend grazing or ranging. Amongst the aims of Work Package 3 (WP3) in AC0114 is to move from set of constants to systems-based approach.

The reasons for changing include improving characterisation and quantification, responding better to changes in farming practices, enabling tracking, including mitigation measures, better differentiate of systems, types, sectors, enabling regional variation to be included. The simplest systems are crops (generally function of N applied) and residue management plus the agri-climatic zones and soil texture. Animal production systems get more progressively complex moving from fully housed poultry production to cattle production.

Farming systems have been described and presented to a stakeholder workshop in March 2011. Data sources have been investigated by the project team in WP3 to support these farm descriptions for use in the inventory. These include both official and industry data sources. The ideal data sources are both stratified and unbiased data, e.g. the June Agricultural Survey-Census, and of adequate sampling frequency across all the UK. If data are biased (e.g. self-selecting, leading edge), the bias needs to be understood. Data sources scrutinised to date include data from the Rural Payments Agency (milk production and IACS), the Farm Business Surveys (FBS) of England, Wales and Northern Ireland (NI) and the Farm Accounts Survey (FAS) of Scotland (all of individual farm businesses), the British Survey of Fertiliser Practice (BSFP), the Farm Practices Surveys (England) and the EU-wide Farm Structure Survey. Animal location and history data are available from the Cattle Tracing System (CTS, GB-wide) and the Animal and Public Health Information System (APHIS) in NI and the GB poultry register. Industry data collection has focussed on the Levy Bodies and carbon footprinting data (e.g. from the E-$CO_2$

project working for DairyCo). Other stakeholders, who may have useful data, have also been consulted (e.g. Environment Agencies, Natural England).

All this is overlaid with data on soils and agri-climatic zones, which is being brought together in WP4, and adds a further spatial dimension to the data collection and interpretation.

## 3. Questions and Answers

Questions were raised after each presentation. The questions and answers listed below are representative of the discussion that was recorded and is archived with the proceedings.

***Q.*** *Given the measurements made to date under AC1115 (methane) are the recommended EFs likely to be different from current values?*

> **A.** It is too early to say, as we are keen to ensure that the UK specific data are properly peer reviewed before recommendations are made.

***Q.*** *Is there any evidence that enteric methane emissions are lower due to inclusion of legumes in the diet, or that nitrous oxide emissions are lower from clover swards?*

> **A.** Work specifically on the effect of legumes is currently outside the scope of the Agricultural GHG Platform. Legumes may be part of the diet in some experiments, but we are not specifically assessing their effect. Concurrent Defra project MIN-NO is assessing the impact of ploughing-in pulse residues.

***Q.*** *As there are important genetic components of enteric methane emissions, is it not more useful to express emissions on a per unit of product (milk and meat) rather than on a per unit of live weight?*

> **A.** Work within AC0115 is specifically investigating the genetic components of enteric emissions, including differences between hardy upland and traditional lowland cattle breeds, and between different breeding-lines for sheep. Baseline emission factors on a per unit of live weight will be generated, which in future could be used as the basis for per unit of product emission factors. Similarly, within AC0116 measurements of crop and grass yield are being made which will allow nitrous oxide emissions to be expressed on a per product basis. The results of the GHG Platform will contribute to future life-cycle assessments and intensity metrics for the UK agricultural sector.

***Q.*** *Have you been able to inter-calibrate the different methods used for measuring enteric methane emissions?*

> **A.** The different measurement techniques are being inter-calibrated against standard chamber measurements with the help of the National Physical Laboratory. Some more novel measurement techniques are being assessed, but they are unlikely to be used to provide emission factors for the improved inventory.

***Q.*** *What are the main opportunities for improvements in emissions efficiency in the UK agricultural sector?*

**A.** The opportunities for improvement have been outlined in the England GHG Action Plan, and include: a) improved livestock genetics; b) improved nutrient management, including accounting for the nutrient value of manure and slurry; c) well designed implementation of anaerobic digestion; and d) integration of manure and synthetic fertilisers in nutrient planning.

***Q.*** *There is significant variation in nitrous oxide emissions at a range of spatial and temporal scales. What is the potential for mitigation through changes in management practices given the large unmanaged variability?*

**A.** Project AC0116 is investigating the sources of variability in nitrous oxide emissions through computer modelling and novel measurement techniques at a range of spatial scales. There are two sources of variability: a) inherent soil properties; and b) fertiliser and livestock inputs. The baseline variability is expected to be greater in grassland compared to arable systems.

Although the intrinsic variability may mean that only small reductions in nitrous oxide emissions may result from changes in farm management, the changes in management may also result in reductions in emissions of other pollutions (such as nutrients and sediment) and improvements in biodiversity. Hence, small improvements may have considerable value when analysed holistically.

***Q.*** *What plans are there to make the results of the emission factor literature reviews and associated databases more widely available? It is critical that the information is shared with the managers of the IPCC Emission Factor Database.*

**A.** Our intention is for all non-IP related data to be placed into the public domain, including the results of the literature review. We look forward to working with the IPCC data managers, and hope that this can be facilitated by a GRA working group.

***Q.*** *What plans do you have to carry out multi-variate analyses of the relationships between enteric methane emission factors and driving variables?*

**A.** We certainly intend to carry out more in-depth analyses, and this will take place as part of the next phase of activity – a review of selected mitigation methods. A parallel task is also carrying out statistical modelling of enteric emissions from a large 'individual animal' dataset collated from the UK and Europe.

***Q.*** *How have you treated outlier data as these may be the most informative observations?*

**A.** We have kept all outlier data in the analysis dataset, and will continue to do so as we agree that they may provide strong clues as to the drivers for emissions.

***Q.*** *As an expert on nitrous oxide I am envious of the quantity of methane measurements relative to nitrous oxide measurements that have been extracted from the peer-reviewed literature. What can be done to improve reporting of nitrous oxide experimental work?*

**A.** A current GRA activity is to develop guidelines on best practice for reporting nitrous oxide experimental work.

***Q.*** *It would be very interesting to make a comparison of the lists of a) most cited papers by the community; and b) the papers rejected due to inadequate information during the literature review. This bibliometric analysis might highlight some issues regarding the selectivity of the scientific community in the citing of papers.*

**A.** We are keen to publish a paper on the data that must be included in journal articles so that the measurements can be included in any future meta-analyses. A commentary on this type of analysis might be included the paper.

***Q.*** *How will the information sourced by the literature reviews be made available to inform farm management activities?*

**A**. We intend to place the reports on the literature reviews in the public domain following peer review. The next phase of the literature review work will specifically address mitigation methods, and we intend to consult industry stakeholders on the methods that will be reviewed.

***Q.*** *Is the review process specifically addressing emissions from organic and organo-mineral soils?*

**A.** Papers on nitrous oxide emissions from organic or organo-mineral soils have not been excluded from the review process, but the number of papers is relatively small and probably inadequate for detailed assessment. A new Defra project on nitrous emissions from 'Lowland Peat' has been commissioned which will provide some new data.

***Q.*** *It is important when estimating enteric methane emissions that we acknowledge the errors that occur in estimating the energy input to the animal from limited information on animal diet.*

**A.** We agree, and in the review of enteric methane emissions we have often come across papers that do not report the energy intake and we have had to make a number of assumptions. The report on the literature review will assess the consequences of these assumptions. A parallel task is also carrying out statistical modelling of enteric emissions from a large 'individual animal' dataset collated from the UK and Europe. This dataset will be used to test the consequences of estimating emissions from 'known' and 'assumed' diet composition and energy intakes.

***Q.*** *Care is required in choosing the correct units for emissions that are reported per unit of product. For example, the GHG Platform should report emissions per energy corrected milk yield, rather than per litre of milk, in order to reflect the variability in fat content of milk.*

**A.** We agree and we will do our best to report using appropriate units. However, for we anticipate difficulties expressing emissions per unit of live weight gain due to the short measurement periods.

***Q.*** *How is the GHG Platform going to address the need to quantify the effects of legumes and concentrated tannins on enteric emissions? This is a large data gap for organic and low intensity farm systems.*

**A.** There may be an opportunity to quantify the effects of legumes on methane emissions by the analysis of historic datasets. However, where data gaps remain we will only be able to document and make recommendations as this is not a specific objective of the GHG Platform.

***Q**. We must not lose track of the critical important of forage legumes. We do know that legumes affect methane emissions, but we must not assume that there is sufficient data available to quantify the effects reliably. So if we do not address the need within this project, we will not be able to answer questions in future?*

**A.** Unfortunately, we need to be clear that our immediate objective is to acquire farm practice and emissions factor data for this particular job of building an improved inventory. This inventory will be flexible enough to incorporate revised emission factors reflecting the effect of diet when data becomes available. There are other Defra work streams that will address some of the issues being raised today.

***Q.** The development of the improved inventory needs to be aware of the needs of decision makers at a range of scales. At the farm scale, it will be important to be able to advise on the consequences of different feeding strategies, whilst at the national scale we will also need to have spatially explicit yield data to compare with spatially explicit emissions data so that we can address future policy questions relating to the optimisation of the landscape mosaic for carbon capture and food production. We also need to be are that GHG emissions are an international issue and provide for accounting of international imports and exports.*

**A.** We recognise that there are many different uses of the data we collect, and anticipate that the GHG Platform would be just one element of a complete accounting of practices and emissions – which might include a national consumption inventory to help optimise the sourcing of UK food requirements.

## 4. Group Activity on Potential Farm Practice Survey Questions

The evaluation of the official and industry datasets carried out in the previous phase of AC0114 has been very fruitful, but it has also illustrated that there clear gaps both within sectors and across the countries of the UK. One task of AC0114 is to scope a future UK-wide survey that will be needed to support the future inventory. Sets of preliminary “straw man” questions were prepared for discussion by the participants at the workshop, with the benefit of access to all the datasets. The workshop participants were divided into sector groups and asked to critique the proposed survey questions. The results of this workshop activity were captured for input into the task of scoping a new UK wide farm practice survey to meet the specific needs of the improved inventory.

### 4. 1 Structure of Group Activity

Laurence Smith introduced the group activity. For this, participants were invited to break-out into pre-allocated groups to review ‘straw-man’ questions for inclusion within a targeted farm practice survey, for monitoring change and improving the inventory calculations.

Participants were divided into the following groups/sectors:

- Dairy (2 groups)
- Beef and Sheep
- Pig and poultry
- Arable and fertiliser
- Grassland and Forage

Potential questions were proposed for each group (for a full list of questions please see Notes 13 to 17)

The questions listed within each area related to a number of different types of required information:

**A) SEGMENTATION:** Questions about basic practices / systems are included so that we can divide a sector into practice sub-sectors, and analyse responses / potentially track changes within the individual sub-sectors. For example, we ask about milk yield because forage feeding practice may differ on low vs high yielding units, and so having asked the question about milk yield we can carry out this type of analysis.

**B) CALCULATION:** Certain questions are included because they are explicit inputs into the GHG emission calculations. For example, animal weight is explicitly requested as it determines energy input and methane emission, and we need information on this by breed.

**C) MITIGATION:** Certain questions are included because they track the uptake of explicit practices to mitigate emissions - that are not implicitly captured and fed into the emission calculations elsewhere. For example, adoption of nitrification inhibitors.

**D) EFFICIENCY:** Certain questions are included because they track changes in production efficiency - that will eventually reveal themselves in the emission calculations, via explicit calculations based on, for e.g., the cattle tracing service and British survey of fertiliser practice. The changes in inputs / animal numbers revealed by these other surveys are the net effect of a number of changes in practice, and would be difficult to disaggregate to assign cause / effect. Tracking changes in

certain 'implicit' methods such as veterinary improvements provides an early warning system, and potentially helps explain the aggregate changes.

The break-out groups were asked to consider the following for each question proposed:

1. Is the question realistic? Will farmers have this data?
2. Is the information requested available elsewhere for the entire UK?
3. What frequency of questioning is required for each question?
4. What method of data collection is appropriate: (Farm visit / Telephone survey / Postal/email survey/ Other)
5. Are there any missing questions that are important for direct methane and nitrous oxide?

### 4.2 Group Feedback

#### 4.2.1 Dairy Group 1

**General comments:**

The group felt the information requested below was generally too complex and questioned the need for all of it. Although a certain amount of future proofing would be good, it is important that the questions support a disaggregation that can equally be supported in terms of new emission factors. For estimating methane emissions – predicted from DM intake - Bruce Cottrill suggested that the minimum that may be needed is (i) number of animals (ii) milk production (iii) concentrate fed. Making assumptions for the ME of the diet, and using the energy required for maintenance and milk production, it would be possible to calculate DM intake.

The group also cautioned against adding to the survey load farmers already have and felt it should be possible to populate much the data requirements using National data collections, in particular recording schemes run by independent consultancies, e.g. Promar, Kingshay, Kite and The Dairy Group. However the data are likely to be biased because they draw from a more forward-thinking set of farmers. This bias must be considered and if possible corrected for through expert opinion or a targeted survey.

**1. Age, liveweight and milk-yield questions:**

**1.1 Please give average milk yield (per annum, not lactation) for the milking herd**

The group felt that this would be hard for the farmer to define and that it would be better to ask about milk yield per lactation and then to derive milk yield per annum from this using calving interval data. It was also suggested that data on milk quality (fat and protein) should be sought.

**1.2 Please give average number of lactations for cows**

This should be available from national surveys (e.g. DairyCo) but the group were not sure why this is necessary/adds value.

### 1.3 Please describe the calving system:

a. **Block spring**

**b. Block autumn**

**c. All year round**

**d. All year round -zero grazed**

This question should be reworded as there may be confusion over what is meant. Relatively few farms run tight calving herds and may have two groups (spring or autumn calving). Since the purpose of this question is to estimate N deposition to pasture, we may need to use an alternative approach. From milk records, we will have the amount of milk produced from grass; can we can estimate N excretion/kg milk produced at grass and get the answer this way?

### 1.4 What is the average calving index?

This information should be available in existing surveys and it would be better to refer to calving interval than index.

### 1.5 Please give the average liveweights for the following categories

a. Cows in milk
b. Dry cows
c. Heifer replacements at 1st calving
d. Heifer replacements at 12 months
e. Calves at birth
f. Calves at 6 months

The group felt that this would be hard for a farmer to define. It would be better to ask for age and weight at calving and then to use models to define the other weights. It was also felt to be important to have information on the predominant breed.

## 2. Diet related questions:

### 2. 1 Please indicate the proportion of each of the following (non-grass) forage types that are fed on the farm (to be broken down by % and livestock categories in Q 1.5):

**a. Grass silage**

**b. Maize silage**

**c. Whole crop cereal silage**

**d. Root crops**

### e. Other forages (please specify e.g. kale, straw)

National data collections, for example held by Kingshay, will have overall figures but not the breakdown. It will be hard for farmers to report proportions and it may be better to ask for amounts fed instead.

### 2.2 For each type of silage fed please provide an indication of Metabolisable Energy and Crude Protein :

- **Grass silage first cut**
- **Grass silage second cut**
- **Grass silage third cut**
- **Maize silage**
- **Whole crop cereal silage**

Farmers will not know this the information. National/regional silage composition data could be available from labs that undertake routine forage analyses

### 2.3 What is the average year-round concentrate use in kg/litre of milk produced?

There is a need to include compound feeds, straights and bulk feeds e.g. brewers' grains. Farmers are unlikely to know the answer to this but should be able to define concentrate use in terms of kg/cow

### 2.4 Do you use Total Mixed Rations (TMR) for cows?

The group felt that this question is not necessary and could be removed.

### 2.5 Please define concentrate feeding rate in kg/animal for:

**a) Cows in milk**

**b) Dry cows**

**c) Heifer replacements at 1st calving**

**d) Heifer replacements at 12 months**

The group felt that this is a reasonable question for a farmer

### 2.6 What proportion of concentrates (by weight) is home produced

This should be amalgamated into question 2.1 above

### 2.7 What is the target crude protein content of the total ration in g/kg (FW)

Farmers will not know this. We need to think of a better way to obtain this information. It may be available from some sources, e.g. the Keenan database, or from independent consultancy databases, otherwise will have to rely on expert judgement.

**2.8 Is buffer feeding of conserved forage used (Yes/No)**

- **a. If so, what type(s) of forage is/are used?**
- **i. Grass silage**
- **ii. Grass silage and maize silage**
- **iii. Grass silage and whole crop silage**
- **iv. Grass silage and whole crop silage and maize**
- **v. Whole crop silage and maize silage**
- **vi. Other (please specify)**

The group questioned whether the answer to this question would be of any practical use without knowing the quantities involved.

**3. Management of replacements:**

**3.1 Do you rear your own replacements? (Yes/No) (a tick-box question, then cattle breeds and numbers would be extracted from the CTS database)**

Farmers should be able to answer this question, but is it of any use without knowing the proportion that is home reared? Even then the group question the usefulness of this information.

**3.2 What is the average replacement rate for the herd (expressed as a %)**

The group couldn't see why this information would be useful

**3.3 What is the average age of calving for heifers?**

This question should be part of question 1.5

**3.4 Do you use sexed semen for heifers?**

RMS data should give this information

**3.5 What breed do you choose for heifers?**

The group couldn't see why this information would be useful

### 4.2.2 Dairy Group 2

**General comments:**

Many of the questions required re-wording to avoid the risk of insulting the knowledge of farm managers, and to clarify what was needed.

Although the group expected that some of the questions could be answered by only some of the managers, it was worth asking all of the questions of everyone. It was anticipated that managers would be very selective in which questions were answered.

The CTS was repeatedly identified as an alternative data source, although it was understood that linking / extracting data might involve considerable effort.

Most of the accurate answers to the proposed questions would come from the more intensive and progressive herds, potentially biasing the results.

**Specific Feedback:**

### Age, Live Weight and Milk Yield Questions:

**1. Please give average milk yield (per annum, not per lactation) for the milking herd.**

Farmer Response: All

Other national data source(s): NMR

Comments: All farmers could provide this information.

Do not ask for yield, but ask for litres sold to avoid approximate responses.

**2. Please give average number of lactations for cows.**

Farmer Response: All

Comments: All farmers could provide this information.

**3. Please describe the calving system:**

**a. Block spring**

**b. Block autumn**

**c. All year round**

**d. All year round -zero grazed**

Farmer Response: All

Other national data source(s): CTS and BOVIS

Comments: Descriptions of calving system are simplistic and confusing. The term 'zero grazing' can have a range of meanings. The CTS could be used to extract calving dates for a representative sample of farms.

**4. What is the average calving index.**

Farmer Response: Most

Comments: Not all farmers will be able to provide a value, and not all will under-stand the terms used. It was thought that many farmers will under-estimate the calving index by 5 to 10 days.

**5. Please give the average live-weights for the following categories**

**a. Cows in milk**

**b. Dry cows**

**c. Heifer replacements at 1st calving**

**d. Heifer replacements at 12 months**

**e. Calves at birth**

**f. Calves at 6 months**

Farmer Response: Some

Comments: Only a few farmers will be able to provide a value. Load cells could be used in an on-farm survey, or expert opinion acquired from consultants providing advice on rations. Proxies for young stock can be developed using straps. Knowledge of breed is critical to validating the provided estimates of live-weight.

### Diet Related Questions

**1. Please indicate the proportion of each of the following (non-grass) forage types that are fed on the farm (to be broken down by % and livestock categories in Q 5 above):**

**a. Grass silage**

**b. Maize silage**

**c. Whole crop cereal silage**

**d. Root crops**

**e. Other forages (please specify e.g. kale, straw)**

Farmer Response: Most Other data source(s): Farm Business Survey; June Agricultural Census – Can be used to identify farms growing forage types.

Comments: Majority of farmers will know which types of forage are used, but not the relative amounts fed to each livestock type. It is important to specify whether the data are required for a winter or summer period.

**2. For each type of silage fed please provide an indication of ME, CP**

Farmer Response: Some

Other data source(s): Regional results of silage analyses provided by service industry, e.g. DairyCo

Comments: Composition data is generated by NIR and therefore only ever an approximation.

**3. What is the average year round concentrate use in kg litre-1 of milk produced.**

Farmer Response: All Other data source(s): National farm recording schemes, e.g. Promar Milkminder and Kingshay Manager.

Comments: Energy content of concentrates varies, but standard ‘book values’ could be used.

**4. Do you use Total Mixed Rations (TMR) for cows.**

Farmer Response: All Other data source(s): A supplier to TMR equipment, Richard Keenan & Co., is prepared to provide feed data for 3,075 farms from across the UK.

Comments: The group were dubious that this feeding strategy is indicative of a progressive farmer.

**5. Please define concentrate feeding rate in kg/animal for:**

**a. Cows in milk**

**b. Dry cows**

**c. Heifer replacements at 1st calving**

**d. Heifer replacements at 12 months**

Farmer Response: Most Other data source(s):

Comments: Most farmers will be able to provide data, but not necessarily accurate values for each livestock type. It is critical to define the time period. Is it worthwhile asking about concentrate use during the dry period, as it represents only a small proportion of total emissions.

**6. What proportion of concentrates is home produced.**

Farmer Response: Most Other data source(s):

Comments: Most farmers will be able to provide data, but the question needs re-phrasing to include 'non-forage supplements' (anything but forage).

**7. What is the target crude protein content of the total ration.**

Farmer Response: Most Other data source(s): Regional results of feed formulation consultants.

Comments: The target protein needs to be expressed in terms of dry matter. It is not clear which ration / period the question applies to.

**8. Is buffer feeding of conserved forage used?**

Farmer Response: All

Comments: Need to specify whether this is indoor or outdoor use of buffer feed.

**8.a. What types of buffer feed are used:**

i. Grass silage

ii. Grass silage and maize silage

iii. Grass silage and whole crop silage

iv. Grass silage and whole crop silage and maize

v. Whole crop silage and maize silage

vi. Other (please specify)

Farmer Response: All

Comments: Need to ask for how long buffer feed is provided.

## Management of Replacement Questions

### 1. Do you rear your own replacements?

Farmer Response: All

Comments: Need to ask whether farm is involved in contract rearing of replacements, or imports replacements from another holding.

### 2. What is the average replacement rate for the herd.

Farmer Response: All Other data source(s): CTS and BOVIS

Comments: What is meant by a replacement rate – culling rate, replacement rate, of all cows, or milking cows? This needs clearer definition

### 3. What is the average age of calving for heifers

Farmer Response: All Other data source(s): CTS and BOVIS

Comments: Use of CTS and BOVIS to link cows / calves data may require considerable effort, but it should be possible.

### 4. Do you use sexed semen for heifers.

Farmer Response: All

Comments: Question should also be asked for cows.

### 5. What breed do you choose for heifers.

Farmer Response: All Other data source(s): CTS and BOVIS

Comments: Clarification required – does this refer to use of a non-dairy bull for first calf? Should question also be asked for cows?

### Management of Dry Cow Questions

#### 1. Please indicate the proportion of the dry period when the cows are at grass.

Farmer Response: All

Comments: Is this really important giving the short dry period?

#### 2. Please indicate the amount of concentrate, compound and by-products etc fed to dry cows over the rearing period and their composition.

Farmer Response: All Other data source(s): Regional results on expenditure by farms on feedstuffs from national farm recording schemes.

Comments: Is this really important giving the short dry period?

### Housing and Manure Management Questions

#### 1. Do you house at all or have a fully outdoor (NZ) system.

Farmer Response: All Other data source(s): FPS

Comments: Question is clumsily phrased. Why not ask directly how many days an animal is housed? It was believed that many farmers would claim to have a zero-grazed system, but animals would actually be turned out for short periods.

#### 2. Please indicate the percentage of the housed period spent on:

a. **Cubicles –without bedding**

b. **Cubicles – with bedding**

c. **Loose yards (on straw)**

d. **Other (please specify, e.g. woodchip or straw pads?)**

Farmer Response: Some Other data source(s): FPS

Comments: The answers given to the question will largely be guesses. There will be no circumstances where there is no bedding material used. We need to consider outdoor facilities such as woodchip corals.

### Bedding Material Use Questions

1. **Please indicate use in kg animal-1 over the house period of straw and woodchip.**

Farmer Response: Some Other data source(s): FPS

Comments: Most farmers will know the bedding type but not the quantity of straw per animal.

## Slurry and Manure Storage Questions

1. **Please indicate type of manure and slurry storage used and the capacity:**

**Storage type**

**Storage capacity (months)**

**Solid manure stored on a solid base**

**Solid manure – field heap**

**Slurry – below slats/below ground tank**

**Slurry - in a tank**

**Slurry - in a lagoon**

**Weeping wall or strainer box**

**Slurry - in another type of store (please specify):**

Farmer Response: Some Other data source(s): SAPM; FPS

Comments: We need to know whether the stores are covered or not (for ammonia emissions if nothing else). .

**General Feedback:**

There is a need to consider whether additional questions can be added to existing surveys rather than creating a new survey. However, it is recognised that existing confidentiality agreements and contracts with survey providers (e.g. FBS) may prevent this.

We were reminded by Lindsay Clothier that we cannot regulate and require that farmers complete a survey. There is very limited opportunity for a new 'statutory' survey.

It is important to clarify whether the survey is intended to provide an improved characterisation of the baseline (present day) or intended to track change. A national voluntary survey similar to the FPS might fulfil the baseline needs and also be used to identify / stratify farm system types that would be the basis of a smaller Panel based survey that would then track change;

It was argued that a telephone or postal survey would deliver questionable data. Accurate data can only be collected by on-farm interview.

An expert is required to review all responses provided by farmers to sanity check the data.

The revised questions need to be trialled with a panel of working farmers and consultants, and a phone help line provided;

We need a risk or sensitivity analysis to inform us of the impact on the inventory GHG emissions of missing / default data values. The proposed questions need to be evaluated for cost-benefit.

The survey methodology would have to be consistent from year to year if it is being used to track change and satisfy IPCC peer review of claimed trends in practice – this is potentially an issue for short-term industry data sources.

The self-selection / progressive farmer bias is less of any issue if the purpose of the survey is to track change, as these are the types of farmer who are more likely to change their practices. However, the 'average' farmer is more important in establishing the correct value for current emission levels.

The UK tend to 'over analyse' data needs / process. We could learn from NZ which took a simple 'expert group' approach to defining typical diets.

There were a small number of missing questions:

- Frequency of milking: 1, 2, 3 times a day etc
- Outwintering of livestock
- Type of milking system: robotics?
- Yard management: Covered; Scraped?

**Some Recommendations:**

*Questions in order of priority:*

- **Milk yield and milk quality;**
- **Animal breed and weight – Although only a few farmers will have measurements of weight, it is still worth asking. Those with robotic milking will have weight estimates. Most farmers will have an estimate of animal weight entered into the ration calculation;**
- **Diet – Concentrate per animal per year;**
- **Grazing calendar – Days at grass; housed; corals etc;**
- **Rations – Forage types and purchased feeds, supported by regional summary data on analyses of silage etc made by service organisations;**
- **Replacement Rate and Fertility;**
- **Housing and Manure Management**

**Simplify**

e.g. is it really necessary to ask about management of all sub-types / periods in cattle life-cycle, e.g. dry cows.

**Frequency:**

A one-off 'baseline' survey could provide valuable data to help define and quantify differences in practice between types of system;

As practices within a system change slowly (but the number of farms on each system may change more quickly) year on year trends could then be detected by analyses of other existing data sources such as NMR and costings organisations if they could be guaranteed to be available year on year;

Else, change could be tracked by a bespoke survey recording responses to five 'big' questions to be asked annually, with a major survey every 5 years. The 'big' questions would be 'efficiency' orientated.

### 4.2.3 Beef and sheep break out group:

#### Age/weight - Beef

Noted that Welsh and Northern Irish farm business survey already collect this information as part of the FBS

As FBS already collect milk and crop yield, it was felt that the most appropriate method of collecting this information was through the FBS.

SAC are currently leading a project to link carcase weight and age/breed to look at incorporating the information into animal breeding values.

BOVISs and APHIS contain information on carcase weight, but not purchased weight

The terms 'transfer in/purchase age and live-weight' would be a more meaningful term than 'starting or buying age and live-weight'. 'Age of stock purchased' could also be used.

It might be possible to add questions on age and live-weight as a 'bolt-on' to QA schemes.

Information on KO% is out-of-date.

BOVIS can inform KO%:

- Suggested that Northern Irish system is used as a proxy
- Determine influence of factor on the inventory and then decide if the information is needed at national scale. This applies to all factors.

If all that is needed is an industry average slaughter weight it already exists in Defra slaughter statistics so for example you have for January UK steers 368.4, Heifers 325, Young Bulls 348.4, cows 314.7 and mature bulls 466. If more detail is required it may be possible to get it through AHDB market research, they collect data on market price, gender and grade, they may well have info on weights and breed alongside that or may be able to get it reasonably easily but probably at a cost. Live-weight data for sales through markets is usually provided to farmers but this would be difficult to collate in a systematic manner.

Sheep age at slaughter will be difficult to ascertain without asking the producer - even a store finisher may be unsure of age because he will not know how old the lambs were when he bought them. If you ask the producer you may only get an estimate of when lambs were born/sold, e.g. "March" because lambing started on 3rd March and finished on 3rd April. There is a need to think about how accurate the data needs to be.

Getting information on weight for individual animals/breeds in sheep systems will be difficult but again an industry average already exists in Defra slaughter statistics, for example for January UK hoggs were 19.6 kg and ewes/rams 25.6 kg.

Every effort should be made to utilise existing age and weight data at slaughter, before turning to primary data collection from farms. Age should be relatively easily determined from CTS or APHIS, weights can be obtained if cattle are sold through a market or abattoir.

With respect to sheep, for the avoidance of doubt and confusion it may be better asking what proportion of lambs are sold for slaughter, as stores and/or for breeding. Age of cull ewes and rams will vary within a flock, but weight should be easily determined.

For buying age and weights (cattle and sheep) the only way this will be obtainable will be by asking producers, although it may be possible to retrieve some information from the auctioneers who may sell store cattle (at least) over the scales. Who asks the producer for this information is open to discussion. It may be possible to retrieve this through the FAS, but it may be time consuming to get agreement that extra questions will be added. It may also take considerable time to get responses.

It may be possible to get quicker access to data by liaising with EBLEX/QMS/HCC to get them to do a survey with their co-operating farmers on their various business improvement groups/projects.

### Age/weight - Sheep

Defra have commissioned a survey that includes age at slaughter.

Suggestion to include age/weight questions as part of FBS

If numbers are known for a system, it may be possible to associate breed with diet.

Noted that health may impact emissions. These may be indirect effects that are not affecting productivity and therefore age and weight at slaughter.

### Grass quality

Low application of N does not necessarily mean that it is of low quality, e.g. grass-clover swards

There is not a good system for classifying permanent pasture. A clearer description might be a) rough grazing/permanent pasture receiving no fertiliser, and b) grassland receiving fertiliser. Likely to produce a wide variety of results (farm specific) and therefore prove difficult to determine reliable aggregate estimates

Countryside Survey may provide information that would help classify grasslands.

Link to altitude, although recognised as being a heroic assumption.

FBS could be used to back calculate concentrates that are purchased or home-grown.

Red clover impacts on quality, N excretion and methane production.

The tannin content of legumes impacts on emissions.

June census on maize silage areas could be overlaid with beef and dairy herd information.

Information on concentrate use could be an add-on to FBS / farm practice survey. Northern Ireland already asks for this information and is probably a good starting point for any subsequent investigation. However to break it down into each category

of stock is a mammoth task! Information on the percentage of the concentrate fed that is purchased or home grown should be readily available for the whole farm but not for each category of stock. Record keeping on diets is likely to be poor on most farms – especially when required in terms of kg/head/year for particular ages and types of beef and sheep. Therefore postal questionnaires and telephone surveys are unlikely to be successful. For determing diets, farm visits would be better, although unless the farmer has records available, on the spot calculation may not be feasible.

With regard to the forage types listed within the example questions, there are a lot of possible combinations which will deter farmers from responding. Also, without quantities will the data be of much value?

Straw should also be listed as a type of forage.

### Housing Information

Slatted pens for rearing and finishing cattle is probably the most common system and worth a specific heading

With respect to slurry/manure storage it is fine to ask about capacity but that doesn't give any indication as to the extent to which that capacity is used. It may also be helpful to explore manure application timings and techniques.

It may also help to consider the proportions of stock in different housing systems. For example you may have cows and calves on one housing system for part of a winter but with the two categories being moved on to different housing systems later. Conversely, a suggestion from DARD representative that "it is likely that different types of stock spend all the housed period in one type of housing".

ADAS manure management survey could be used to provide information: noted that this may have to be repeated.

If there was a grant scheme, then it could be added to the application form for the grant

Environment Agency (EA) has to grant licences for sewage sludge applications and therefore they are a possible source of information.

EA have issued a certificate for every slurry tank that has been built since 1991, and therefore they should information on slurry tanks.

Link to DARDNI website showing method of calculation of storage capacity of manure storage: http://www.dardni.gov.uk/fnms-storage-workbook.pdf. This document was used to assist applicants to the Fam Nutrient Management Scheme (FNMS) in estimating the volumes of slurry and dirty water produced, existing storage capacity and additional storage capacity required to comply with the requirements of the Scheme.

Straw – farmers very unlikely to have made a calculation of straw use for the housed period or have the records needed to calculate. However, if straw is bought in the information will be available from the FBS.

When considering straw may wish to consider the difference between straw for feed and straw for bedding. Equally it may be necessary to consider the difference between the impact of home grown straw and purchased straw.

Will probably know amount of straw purchased/used, however will have difficulty in allocating to category of stock. Suggestion to work out number and age of stock housed during winter and convert to Livestock Units (LU's). This will provide an estimate of straw usuage per LU.

Suggestion that for grass quality and housing an occasional survey – maybe every three years, would be sufficient. It might even be possible to integrate some questions with the EU Farm Structures Survey.

The proportion of lambs sold for slaughter or kept for replacements: this should be relatively simple to obtain through use of current flock register although older ewes born prior to (2005?) do not have to be tagged unless moved off the farm. Unlikely to be many of these!

Fully updated for SPS and new rules for individual sheep records (DEC 09)

The "Holding (Flock) Register for Sheep & Goats" records ovine (sheep and goat) movements on/off a holding.

Record over 400 ovine movements per book:

- Date of movement
- Running total (with subtotals for ewes, ewe lambs & other)
- Type of movement (purchased, sold, dead, born...)
- Number of sheep or goats moved
- Category of sheep or goats moved (ie., ewes, ewe lambs, rams, etc.)
- ID number
- Transporters name & vehicle registration
- CPH number (or address) for holding of departure
- CPH number (or address) for destination holding
- Comments (use this for additional information including cause of death, name of buyer or seller and market lot numbers).

Possible solutions for obtaining all the information that is required would be the use of a network of monitor farms to get the detailed information that is required.

### 4.2.4 Grassland and Forage break out group:

#### The grazing system:

- Do we really need to capture information on cattle housing?
- Add a ‘zero grazing’ category
- Grazing intensity index?
- Do you have any sacrifice areas? (Would need to specify that these are grazing sacrifice areas and not land set aside for woodland etc)

#### Presence of clover and high sugar grasses in grassland fields

- If farmers get their seed mixtures from manufacturers – they may not know the proportion of grass: legume or % high sugar grass quantities
- Consult seed wholesaler’s recommendations
- A survey can be conducted – What mixes wholesaler’s produce

- Ratios of clover and high sugar grass in grasslands will vary depending on what the land is used for. Silage and pasture should be split as they are fundamentally different due to management applied
- Also - Forage plot areas and solely grazed areas
- For high sugar grasses – they are all specific brands ABE (from Aberystwyth) so they'll all be logged by seed suppliers
- It is likely that the grasses would be split as (e.g.) 50% rye sugar and 50% condensed sugar as 100% would be too expensive

- With respect to grass quality it may be necessary to give some consideration to sward structure, e.g. clover content, but what about purchased fertiliser use? The British Survey of Fertiliser Practice may offer something on this?
- Equally does age of sward impact grass quality?

**Land drainage status** (little time spent discussing this)

- Identify compaction areas from tractor traffic?
- Compaction alleviation occurring? This is normally carried out in the top few inches
- This would be important for identifying potential hotspots for $N_2O$ loss and carbon storage
- Data on this area would also be useful for LULUCF, need to talk to the delivery team at CEH when designing questions

### 4.2.5 Arable and Fertiliser Practice

**Questions on Nitrification Inhibitors and Urease Inhibitors:**

**a. Do you use nitrification inhibitors?**

**b. If so, what on what crop types (including grass)?**

**c. For the given crop type, what area of land receives nitrification inhibitors? (Unit of area e.g. ha or a % of the total land area for the crop)**

**d. Are the nitrification inhibitors applied with fertiliser or manure?**

- The group were happy with the structure of these questions
- Potential to collect this information in BSFP
- Limited use of nitrification inhibitors in Northern Ireland
- This question was viewed as less important than the other questions discussed

**Application timing and number of splits:**

**What crop area received Nitrogen fertiliser in the given month? (This would rely on also finding out the total area of a crop elsewhere in the survey).**

- Not discussed in detail, all agreed with the question.

**Questions on Clover as an N source:**

**a. Do you actively use clover as a nitrogen source?**

**b. If so, which crop types are undersown with clover? e.g. grass leys (defined as grass less than five years), permanent grass (defined as grass five years and over), cover crop**

**c. Do you use clover as an alternative/supplement to fertiliser N? / Do you reduce your fertiliser application as a result of clover use?**

- Include other legumes, not just clover
- Additional question on rotations and the type of enterprise
- Over time, it is likely that more lucerne will be grown
- We don't have enough data on legumes in a rotation (more home-grown protein is likely in the future)
- Capture the imprecision of fertiliser use (e.g. after a legume, is less N actually applied?)
- Capture decisions that are effecting the amount of N applied (e.g. crop type, soil type)
- BSFP can be used to link previous crop with the following years fertiliser practice

**Arable cultivation practices:**

**Please provide the proportions of tillage type by area for each crop type:**

**Inversion tillage - autumn**

**Inversion tillage - spring**

**Reduced Tillage autumn**

**Reduced Tillage spring**

**Direct drilling, autumn**

**Direct drilling, spring**

- Proportion of tillage type by soil type is important
- Suggestion to call 'inversion tillage' 'plough-based inversion tillage'. Also a reminder that in Northern Ireland spring sown cereals form the larger proportion of the total cropping area.
- Add strip tillage to the list (this is particularly important on Maize)
- Question required to determine whether they are doing continuous min. tillage, or some conventional and some min. till (e.g. ploughing out every five years)
- Difficult to define tillage practices e.g. reduced tillage can mean different things
- Suggestion to add other legumes to the Beans and peas row on the list of crops
- Organic content of soil may interact with cultivation method

• Characterising the soil is important

**Arable residues**

**From what proportion of crop area grown is straw removed?**

**a) Wheat**

**b) Barley**

**c) Oats**

**d) Oilseed rape**

**Where harvested, what yield of straw do you get per ha, e.g. bales per ha**

**a) Wheat**

**b) Barley**

**c) Oats**

**d) Oilseed rape**

• Suggestion for addition of a question on bale type/size to the yield section (e.g. round bales, square bales)

• The first question is OK for an exclusively arable producer but mixed farms might finds it harder to answer (e.g. with straw used for pig bedding)

• The emphasis of these questions is on what is baled and removed from field to determine how much of the non-harvested crop is going back to the field, however knowing how much is taken off doesn't say how much is left

**Drainage**

**Question1**

**a) What is the area of arable land that is under-drained?**

**b) What is the area of under-drained land that is ALSO mole drained?**

**c) If applicable, what frequency do you aim to repeat moling?**

**d) Please state the area of your under-drained land that has been affected by the following issues in the last three years: (please only state the area of land that has been affected):**

**a. Drain failure causing an artificial spring or blow out**

**b. Yield reduction due to sustained water-logging**

**c. Risk of soil damage (e.g. rutting) due to seasonal water-logging**

**e) What area of drains have you replaced or reconditioned in the past 10 years?**

**Question 2**

**Please indicate the frequency of deep ploughing/sub-soiling:**

**a. Every 1-2 years**

**b. Every 3-5 years**

**c. Every 6-8 years**

**d. Every 9-10 years+**

• It may be helpful to qualify the term 'under drained' by adding 'man-made'

Define soil wetness (could define as trafficability)

• Generally happy with the first question, although regarding "f)" farmers may find it easier to determine as a proportion

• Recommended rephrasing of question 2. What is the aim of the question – is it to determine compaction?

• Additional information required for question 2: How, where and when is the deep ploughing/sub-soiling? Do they dig a trench to check it is required?

• Farmers might find it hard to say what drains are working

• Information on organo-mineral soils

## Precision farming

The questions in Section 2 of the 2009 Farm Practice Survey provide a useful guide including a tick box of precision farming methods such as GPS, soil mapping etc.

• Define precision farming

• Additional information required: Are farmers using a crop protection plan? Are they using fungicides appropriately? Is the variety choice right?

• ½ of fertiliser recommendations are within 50kg of the fertiliser recommendation

## Additional questions

• All questions should be asked in context of:

  - What soil type is the product being applied to?
  - What is the crop area?
  - Where on the farm, where in the country?
  - Rotation
  - Drainage type

• Soil amendments that alter practice e.g. addition of organic matter (we don't have good survey information on this).

• Frequency of farmers meeting their bread-making requirements?

**General comments**

- Capture data on the dynamics of a system
- Is FPS the best way to get farmers to admit they are not putting on the correct amount of N for crop requirements?
- Do not ask questions that will not get answered
- Ask questions that are relevant going forward/future-proof the survey
- Missing questions on organic manure use and crop rotation details?
- Method of collection: face-to-face would be best, given the nature of the questions. Telephone would be a good second choice but good scripting support would be required.
- It would be helpful to seek advice from statisticians with regard to the frequency of questioning.

### 4.2.6 Pigs and Poultry

**Please define the outdoor stocking density, for the following sections of the pig herd:**

**Sows (low / medium / high)**

**Growers (low / medium / high)**

**Finishers (low / medium / high)**

**Is it possible to define stocking density range for each category (low, medium and high)?**

There may be unwillingness within pig industry to answer questions.

Sows – commercial norm is 10 per acre/25 per hectare and, except for organic, you won't see much variation from that. So question could just be – "is enterprise organic or not?" and the answer will give the stocking rate.

Growers (suggested 2% outdoors from FPS and 1997 survey Scotland) - Usually have an arc and a run (10-15 sq ft per pig).

Finishers – very few outdoors. If they are then have tent/arc with a big run.

Given the fluidity of the industry, ask question annually.

**What are the rotational frequencies of outdoor pigs?**

Breeding herd move every 1-2 years (good land for pigs - move every 2 years, heavier land – move annually).

Need to ask soil type with question.

Outdoor growers – Generally outdoors for 10 weeks (in arcs) until 30-35kg and then go onto finishing herd and arcs are moved elsewhere to take on new batch. When they first go on there's some grass cover (organic holdings may retain grass cover due to lower stocking rates) – may affect emissions?

**Please define the type of shelter used for outdoor systems:**

There is no obvious impact from different shelters. Question may not be worth asking.

**Please indicate the proportion of the finishing herd that is liquid fed?**

Not sure this will have an impact – only obvious difference is that higher liquid feed may cause higher liquid excretion. Possible to have balanced diets using liquid.

### Please indicate the proportion of the finishing herd that is by-product fed?

See above.

### Do you include synthetic amino-acids within the diet? (yes/no)

Answer will be yes unless herd is organic so may not be worth asking.

### Please indicate CP content of diet for different pig types:

| | |
|---|---|
| Lactating sows | 18-20% |
| Dry sows | 16-17% |
| Boars | 16-17% |
| Weaners | 22% |
| Growers | 20% |
| Finishers | 18-19% |

Need a matrix design for the table with this question. 2-3 diets are used for weaners and a couple for growers - account for phased feeding.

Don't need to ask CP every year as it's fairly uniform across the industry just ask often enough to pick up any new products.

British Quality Pigs (BQP) might have data / information.

### Please enter proportions in different housing systems

Recorded in FPS (but not in rest of UK).

Don't repeat Q annually but ask every 2-3 years once a baseline has been established.

Part-slatted is only seen in buildings that are 20-30 years old.

There's a Defra funded project (by AEA) on ammonia which may have asked similar questions – review is on Defra webpage.

### Are synthetic amino acids used in poultry diets?

Yes, unless organic then bound by the regulations. Therefore, may not need to ask the question. Question about crude protein could be included here.

### Please enter proportion of laying hens kept in the following housing types: cages (enriched), stilt, aviary, free range, organic

Change the categories to match the industry: enriched, free-range (including organic), barn. But also remember need for hindcasting.

Aviaries exist within barn and free-range.

These questions can be answered by poultry register and BEIC [British Egg Industry Council] (BEIC get Kantar data so also have data for Northern Ireland).

Enriched cages need to ask 2 questions – frequency of removal? Forced air drying or not?

Free-range – about 50% of current free-range are multi-tier aviaries with air-drying (not quite at the drying status of enriched cages but very close).

Things can change very quickly for type of housing system.

**Please enter proportion of broilers kept in the following housing conditions: housed (with thinning), housed (without thinning), free-range, free-range (organic)**

BPC (British poultry council) may know. Could also be a question added to the poultry register.

These are market-led: tends to change based on what customers are wanting.

Free-range tends to be a low percentage for broilers (<5%) and those will only be out on the range for the last week or so.

**Please enter proportion of turkeys, ducks and other poultry managed as: fully housed, barn, free range, organic.**

BPC (British Poultry Council) might have data / estimates.

Additional question: What proportion of the turkey crop is for Christmas and what proportion is for the rest of the year? Variation due to this means that surveys at different times of year give different numbers of birds.

**For all free range poultry, please indicate the proportion of time spent by birds outside:**

Depends on weather / cover on the range. Some estimate 20-25%. Bristol suggested 70%.

Bristol University - transponders on birds, tested when they went through the port-holes.

Farmers might not know the answer. Probably best answered by expert opinion.

**For all housed poultry, please indicate typical housing capacity in square metres and number of birds/house**

Could ask for stocking densities at the start (when house is stocked).

BEIC – has factsheets for each housing type

Free-range houses can be multi-tiered so using floor space and number of birds will not give a helpful answer.

Potentially difficult to answer and potentially not useful enough to be worth the difficulty.

**For all housed poultry, please indicate type of litter used and tonnage: wood shavings, straw, shredded paper, other**

Broilers – 0.2 tonnes wood shavings per 1000 birds.

**Additional question** – what is the down-time between crops for broilers? For layers?

Broilers usually about 6.5 crops per year (approx 42 day cycle)

**Please indicate straw use in kg per animal over the housed period.**

Not discussed.

**Please indicate the proportion of the poultry manure that is burnt on farm or taken to be burnt in a power station.**

Need a license to burn manure so won't tend to happen now but might in the future.

Selling to power stations was popular in Scotland in the past (approx 80%) and also in Northern Ireland.

For an individual farm it will be either 100% or none.

**Please indicate type of manure and slurry storage used and capacity: solid manure on a solid base, solid manure (field heap), slurry (tank), slurry (below slats/below ground tank), slurry (lagoon), slurry (other)**

Could ask whether it's spread directly to the land or whether there is separate manure storage (possibly with drying).

Could ask about lagoons and how they're covered.

**Missing questions:**

Ask about pig slurry – is there any separation? Use of additives?

Poultry – do they use products that might reduce ammonia emissions? Litter treatment to alter pH?

### 4.3 Summary of feedback from break out sessions

Feedback from the break-out group session highlighted a number of important issues, one of the most prominent being the need to clearly define the information that will be essential for annual greenhouse gas reporting purposes. This is important to ensure that the questions posed support a disaggregation that can be supported in terms of new emission factors. Despite this, the importance of including some questions as monitors of farm efficiency and for 'future-proofing' purposes was highlighted. For example, we currently lack sufficient evidence to determine the contribution of legumes in ruminant diets to reducing enteric methane, however the use of legumes can serve as an explanatory factor for reductions in mineral fertiliser, and their use could potentially be incorporated directly as more evidence develops.

It is also important to ascertain whether survey questions are needed to improve characterisation of the baseline, or if the questions are being asked in order to track changes over time. It was suggested that a national, voluntary survey similar to the Farm Practices Survey might be able to fulfil baseline needs whereas a smaller, targeted expert panel survey could then be used for tracking change. This could entail using groups of industry experts to help determine target crude protein contents of typical diets and it was highlighted that this approach has been used as part of the inventory development work in New Zealand. There were also several notes of caution to avoid adding to the survey load that farmers already have. In this context the importance of considering whether new questions could be added to existing surveys was highlighted. It was also suggested to trial revised questions with a panel of working farmers and consultants to gather feedback.

There is also a need to temper ambitious questions in line with what farmers are likely to know, e.g. farmers are unlikely to be able to report straw use on a kilogram basis for different classes of stock. In such cases, the degree of accuracy should be considered, i.e. is an estimate sufficient? The favoured method of collection was a face-to-face interview, several workshop attendees commented that telephone based or postal surveys could result in less reliable data, although this needs to be reconciled with the cost implications of conducting farm visits. A suggestion was also made to use a network of monitor farms to determine answers for some of the more in depth questions, for example the protein content of the diets fed to each class of livestock. Industry data could also be used in some cases, for example regional results of silage analysis could be sourced via DairyCo. There was also a need to establish a link to soil type for many of the questions posed, particularly for those questions relating to drainage and stocking density. Some questions could also be dropped as the relevance was not apparent, for example questions relating to the types of shelter used for outdoor pig systems. Feedback on the required frequency of questioning varied greatly depending on the question being asked, for example rations for pigs and poultry are unlikely to change much over time whereas the use of nitrification inhibitors may fluctuate more rapidly. It was recommended to seek advice from statisticians within the project in this respect.

### 4.4 Plans for the coming months and concluding remarks

Work over the coming months will build on the feedback gathered throughout this knowledge exchange workshop, with work package 3 of project AC0114 focusing on the development of recommendations for a UK-wide targeted survey of farm practices. This process will involve further consultation with stakeholders within industry and Government bodies.

Stakeholders attending the meeting were reminded that the principle points of contact for those wishing to engage with the Platform and its activities are Laurence Smith (laurence.s@organicresearchcentre.com) and Tom Misselbrook (tom.misselbrook@rothamsted.ac.uk). Attendees were also reminded that regular updates on the Platform's activities can also be found on the projects' website: www.ghgplatform.org.uk.

The workshop ended with Laurence Smith, Knowledge Exchange Officer and Adrian Williams, Project Science Director thanking attendees for their time and input.