Agricultural GHG Emissions: A workshop to explore alternative methodologies for national inventory estimations

MAF Technical Paper No: 2011/75

Full report prepared for Ministry of Agriculture and Forestry
By AgResearch
June 2009

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ISSN 2230-2794 (online)
ISBN 978-0-478-38719-3 (online)

September 2011

Ministry of Agriculture and Forestry
Te Manatū Ahuwhenua, Ngāherehere

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Publisher

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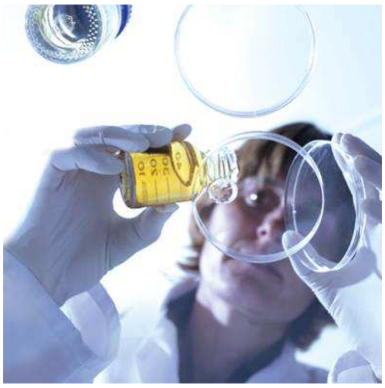

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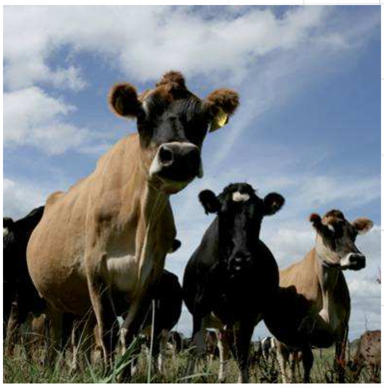

Agricultural GHG Emissions: A workshop to explore alternative methodologies for national inventory estimations

Client Report for MAF

June 2009

Dr Harry Clark and Mr Alasdair Craig

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1. Summary

The calculation of greenhouse gas (GHG) emissions from agricultural activity in NZ is an essential component of the National Inventory Report (NIR) required annually by the UN Framework Convention on Climate Change (UNFCCC). Continuous evaluation of the adequacy of the New Zealand approach to calculating GHG emissions is needed, particularly in order to account for mitigation measures which will increasingly form part of agricultural activity in NZ, as well as to enable comparisons between sources of emissions at the farm scale, which may eventually be necessary to drive those emissions down.

For this purpose, a working group of agricultural scientists, statisticians and policy experts was convened at MAF, Pastoral House in Wellington, on 3rd June 2009, to explore what refinements might be made to the existing methodology, or what alternative methodologies might be adopted, to achieve a more robust and transparent process for inventory compilation.

The working group identified the general issues associated with GHG inventory calculations and explored these in detail under the headings of: spatial issues; temporal issues; issues around moving to the use of mechanistic models; issues of using direct measurement rather than estimation approaches; and issues around the ability to obtain and use real time data.

Potential methodologies based on three different approaches were then identified for consideration. The first of these was an adaptation of the current methodology using regional data, while the other two involved moving to calculations based on emissions per product and emissions per farm respectively. These options were analysed in-depth, using assessment criteria defined and prioritised by the group. A list of pros and cons was compiled for each approach in terms of such things as data availability, cost, complexity and accuracy. .

The group concluded that there were merits to all three options identified. Option 1 presented a relatively simple, low cost way of improving the inventory and could be adopted with immediate effect. Option 2 would be a radical departure from the current methodology, but could increase accuracy and have potentially significant alignment with the Emissions Trading Scheme. Option 3 would also increase accuracy, have the advantage of being relevant to farmers and have significant alignment with the Emissions Trading Scheme. Options 2 and 3, however, would be more complex and costly, and issues would need to be resolved around data collection and computation.

Representatives from Meat and Wool NZ were consulted for their knowledge of data availability, and their views on the three options considered, before recommendations were made.

The recommendations from the working group are that the regional approach for calculating emissions from dairy should proceed immediately, and that further work be conducted on the feasibility of using Options 2 and 3 for future

inventories. This work should involve pilot studies for 1990 and the current year so that the alignment of any new emissions estimates with existing estimates can be assessed. In addition, these studies need to make some preliminary assessments of the uncertainties in these alternative methodologies.

2. Introduction

New Zealand is a Party to Annex 1 of the UN Framework Convention on Climate Change (UNFCCC) and, as such, is required to prepare an annual National Inventory Report (NIR) on greenhouse gas (GHG) emissions.

The Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC 2006), and the IPCC Good Practice Guidance (IPCC 2000) reporting guidelines on annual inventories, describes the scope of the NIR. This includes input data, methodologies, background information and the process of inventory compilation, as well as a requirement to give details of any recalculations of historical inventories. There is rigorous review of submissions from Annex I Parties to assess the transparency, completeness, overall quality and ongoing improvement of the inventories.

As well as complying with the UNFCCC reporting guidelines, the NIR is intended to inform Government departments, institutions and other stakeholders in NZ, of the level of greenhouse gas emissions, in order to meet targets under the Kyoto Protocol. An informative NIR allows data suppliers to become fully aware of the importance of their contributions.

Agriculture accounts for almost 50% of GHG emissions in NZ and a significant component of the annual submission to the UNFCCC secretariat is a national inventory, compiled by MAF. The inventory details emissions of methane (CH_4) from livestock, which accounts for 64% of agricultural emissions, and nitrous oxide (N_2O) from animal excrement and synthetic fertilizers, which accounts for 33.8% of agricultural emissions. The remaining emissions arise from such things as the burning of tussock grasslands and the cultivation of peat soils.

Methane emissions for major livestock classes (cattle, sheep and deer) are currently based on a Tier 2/3 model using detailed livestock characterisation and productivity data to derive annual emissions per animal, which are multiplied by the total livestock in the population, and aggregated as a national figure. Annual emissions per animal for major livestock classes are re-calculated annually and hence change in line with changes in animal productivity and size. Minor livestock emissions use a Tier 1 system based on default emissions factors which do not change annually.

Nitrous oxide emissions derive mainly from agricultural soils and are calculated, using emissions factors applied to the amount of nitrogen (N) excreted per head of livestock per year, multiplied by the number of livestock plus the quantity of N fertilizer applied. The quantity of nitrogen excreted per head for the major livestock classes is calculated annually and, as for CH_4, is influenced by animal size and productivity. Minor livestock species use a fixed value for N excretion. National figures for the quantity of N applied are supplied by the fertiliser industry.

Aside from the IPCC expectation that inventories will demonstrate ongoing improvement in quality, the extent of GHG emissions contributed by agriculture makes the accuracy of the inventory from this sector important in terms of NZ's

Kyoto commitments. Continuous evaluation of the adequacy of the New Zealand approach to calculating emissions is therefore essential, especially since the calculation of national GHG inventories is a relatively recent activity. For example, the current IPCC approved methodologies are not ideal to allow for the factoring in of GHG mitigation measures which will increasingly form part of agricultural activity in NZ. Furthermore, the current method, which provides national aggregate figures, does not allow for comparisons between sources of emissions at the farm scale which may eventually be necessary to drive those emissions down. Ultimately it will be farmers who will need to lower emissions, and their awareness of the extent of farm emissions will be key to implementing reduction measures.

For these reasons, a working group of agricultural scientists, statisticians and policy experts was convened at MAF, Pastoral House in Wellington, on 3rd June 2009, to explore what refinements might be made to the existing methodology, or what alternative methodologies might be adopted, to achieve a more robust and transparent process for inventory compilation.

Present at the workshop were:

Anne-Gaelle Ausseil	Landcare Research
Darren Austin	MAF
Len Brown	MfE
Dave Clark	Dairy NZ
Harry Clark	AgResearch
Tim Clough	Lincoln University
Cecile de Klein	Agresearch
Donna Giltrap	Landcare Research
Frank Kelliher	AgResearch
Keith Lassey	NIWA
Paul Muir	On-Farm Research
Andrea Pickering	MAF
Gerald Rys	MAF
Guy Saunders	Statistics NZ

The meeting was chaired by Harry Clark

3. Identification of Issues

The working group began with a "blue skies" discussion around the issues associated with making changes to the inventory structure. This discussion agreed on some givens for any new methodology and raised a number of questions for further consideration. These were:

3.1 Issues - givens

- Any alternative structure must be fit for purpose in terms of cost and practicability.
- Any improvements should be targeted on the factors contributing the most to uncertainty.
- Any alternative structure must pay attention to issues of data / information handling.

3.2 Issues – questions

3.2.1 What do we want from the inventory?

National inventories are not simply an annual stock take of emissions. They are used to meet international obligations, to predict future liabilities under international agreements, to determine priority areas for emissions reduction investment, and they are likely to be used to assist in assessing liabilities/allocations in any future emissions trading scheme. *The needs of various stakeholders therefore have to be considered when contemplating inventory development.*

3.2.2 What is the ideal basis for the structure of the inventory, e.g., regions / farms / climate zones / soil types / products / life cycle analysis?

Globally, agricultural inventories are generally compiled on a country-wide basis, although there are some exceptions to this, such as Australia, which compiles its emissions on a state basis and aggregates to the national figure. However, as inventories become more sophisticated there is a need to decide on the appropriate unit upon which they should be based. The starting point for agricultural inventories is the animal, and emissions are calculated from emissions per animal of either methane (CH_4) or nitrogen (N) excreta and the total population. However, other approaches need to be considered. In New Zealand, reporting dairy cow emissions on a regional basis has already been explored and found to yield different results from those obtained using a national aggregation of the same data. For nitrous oxide (N_2O), basing an inventory on soil and climatic regions may be preferable to the national approach adopted by New Zealand. It is possible that the farm could be the appropriate unit since GHG emissions arise from, and will ultimately be influenced by, decisions taken at that scale. More radically, emissions could be calculated on a unit of product basis, at local scales, and aggregated to the national scale using data on the total amount of product produced? *Issues of scale are therefore critical to any proposed changes to the current national inventory methodologies.*

3.2.3 Is a "top-down" or "bottom-up" model preferable?

National inventories are "top-down" in approach in that national average data are used for such things as productivity and fertiliser use. National total population data and national average values are used for determining the quality of the diet consumed. It may be that adopting a bottom-up approach is preferable, i.e. the inventory is structured to better represent the activities undertaken by farmers making it more relevant to a wider group of stakeholders. *This issue is highly linked to the issue of the most appropriate scale.*

3.2.4 What is the availability of productivity data?

Animal productivity data are crucial to any GHG inventory, however it is structured, and data availability may severely constrain the approach adopted. However, inventory development will be too constrained if historical data availability limits the adoption of improved methods. *Future inventory development should clearly define data needs rather than be constrained by current data availability.*

3.2.5 How can mitigation measures be captured by the inventory?

Reducing GHG emissions to the atmosphere is a global priority and national inventories provide a measure of the progress individual countries are making. The adoption of proven mitigation technologies will reduce emissions in practice, but unless national inventories can incorporate these mitigation technologies, no credit can be obtained under the current international treaty (the Kyoto Protocol) for the adoption of these measures. The current New Zealand inventory approach cannot easily accommodate mitigation practices (e.g. stand off pads and the introduction of new forage cultivars). *The ability to incorporate a broad range of mitigation practices must be a crucial factor in determining any changes to the current national inventory approach.*

3.2.6 How can the inventory be made more transparent and accurate?

International reporting obligations require New Zealand to produce an inventory that is as transparent and accurate as possible. New Zealand has passed international scrutiny in this respect for its current inventory approach. However, transparency can be viewed in a broader context since the inventory is now being scrutinised more closely by a wider range of stakeholders. *Transparency to a wide group of stakeholders is therefore crucial.* Having an accurate inventory is taken as a given, but how far should this be pushed is open to question. The use of real-time data (e.g. monthly climatic data to determine N_2O emissions rather than reliance on emissions factors that are the average value under a range of climatic conditions) could improve accuracy, but may increase annual variability and create greater uncertainty when forecasting emissions. Currently parts of the national inventory are influenced by real-time data (e.g. population changes) but other parts are not (e.g. environmental influences on the timing of milk production and the slaughter of animals). This gives rise to an important philosophical question. *Should national inventory calculations use real-time data wherever possible to better reflect short-term variations (e.g. monthly, seasonal) in emissions due to environmental and management factors, or should they represent the average situation occurring over a longer timeframe (years)?*

3.2.7 To what extent is moving to mechanistic models viable?

The underlying biology of both N_2O and CH_4 emissions is highly complex, although national inventories in general predict emissions using simplified procedures. However, more complex models based on the underlying biology are available, and consideration needs to be given to their suitability for use in the national inventory. The question is raised: *to what extent will the use of complex mechanistic models increase accuracy, reduce uncertainty and facilitate the incorporation of mitigation practices into the national agricultural inventory?*

3.2.8 Is it possible to measure emissions directly from New Zealand agriculture using either satellite imagery or via a network of local representative ground-based sampling points?

National inventories are often described incorrectly as providing “measurements” of GHG emissions. In fact, they estimate national emissions at an annual timescale using information derived often at completely different spatial and temporal scales (e.g. animal and plot scale). An important question is therefore: *is it feasible, at some stage in the near future, for New Zealand to move away from estimations of agricultural GHG emissions via top-down calculations, to continuous, direct measurement of emissions at the local and/or the national scale?*

3.2.9 Issue categories for further consideration

Although discussed as separate issues, many of the above points are inter-related. Further discussion resulted in them being assessed as falling into the following main categories for further consideration:

- Spatial issues.
- Temporal issues.
- Issues around moving to the use of mechanistic models.
- Issues of using direct measurement rather than estimation approaches.
- Issues around the ability to obtain and use real time data.

Each category of issue was then further explored as follows:

Table 1 Detailed breakdown of identified issues

Spatial	At what spatial level could information potentially be gathered? • Local Territorial Authority (LTA) regions – particularly relevant for population data as it is readily available at this scale. • LIC regions – dairy productivity and population data readily available. • Meat and Wool NZ areas – sheep and beef data (population and limited productivity) available at this scale. • Environmental domains (LENZ) – population data can be modelled at this scale or perhaps aggregated from Statistics New Zealand mesh grids data. • Land Use Capability (LUC) classifications - population data can be modelled at this scale or perhaps aggregated from Statistics New Zealand mesh grids data. • Rainfall and temperature – broad classifications exist and population data can be modelled at this scale or perhaps aggregated from Statistics New Zealand mesh grids data. • Soil type - broad classifications exist and population data can be modelled at this scale or perhaps aggregated from Statistics New Zealand mesh grids data. • Slope – classifications can be developed and population data can be modelled at this scale or perhaps aggregated from Statistics New Zealand mesh grids data. • Farm – MWNZ classify farm types by region and a farm type classification by region may be possible using a combination of LIC and DairyNZ approaches. Population and productivity data are available at this scale. • Catchment - classifications exist and population data can be modelled at this scale or perhaps aggregated from Statistics New Zealand mesh grids data.
Temporal	At what timescale could information potentially be gathered? • Multi-year averages - activity and environmental data exist at finer timescales but is it more appropriate to average these over longer periods and calculate over longer timeframes to reduce short-term fluctuations in emission estimates and perhaps uncertainty. May be highly relevant to an

	ETS & liability forecasting where more "certainty" over potential liabilities is needed. • Annual – this is the default reporting timescale and for many countries the default calculation timescale. Activity data are also often only available at this timescale. • Seasonal – provides for the better incorporation of the factors influencing emissions (e.g. climate, diet composition etc.) and perhaps mitigation technologies, but requires modelling to obtain activity data at this timescale. • Monthly – The default timescale for calculations in the current inventory calculations. Requires modelling to obtain activity data at this timescale, but provides a better framework for accurately assessing emissions (e.g. changes in chemical composition of the diet) and the incorporation of mitigation technologies (e.g. DCD only active in some months of the year). • Weekly – can better accommodate environmental influences but requires modelling to obtain activity data at this timescale. • Daily - can better accommodate environmental influences but requires modelling to obtain activity data at this timescale. • Diurnal pattern.
Mechanistic models	How viable is the use of mechanistic models as a basis for the inventory? The potential use of mechanistic models was discussed at length. Mechanistic models are based on the biological processes involved and so should provide a more accurate prediction of emissions. However, incomplete understanding of the biological processes involved in determining emissions means that these models have to be carefully assessed for their ability to predict emissions at the national scale better than simpler approaches. In addition, in trying to incorporate the range of factors that influence emissions they are often data hungry and these data do not exist at scales relevant to the inventory (e.g. highly detailed description of the soil at a paddock scale and/or daily climatic data at a specific location). In practice, therefore, these models have to rely on "average" inputs which limit their predictive ability in practice. While mechanistic models would provide valuable sensitivity to mitigation technologies, there needs to be a balance between their use and their accuracy. Improved accuracy cannot be guaranteed since, as more processes are involved, more data are required and the uncertainty around these data (e.g. soil carbon %) may be high. The consensus view was that mechanistic models are not yet sufficiently sophisticated to underpin the inventory. A

	significant development effort is needed over the next 5-10 years of before the models could be reliably deployed to provide consistent data as a basis for the inventory. There is potential, however, to use them to enhance the current inventory approach without replacing it, i.e. they can be used to develop and validate simpler algorithms that better predict emissions using a narrower activity dataset.
Direct measurement approaches	How viable is it to consider measuring emissions as opposed to estimating emissions? Making real time measurements of emissions has great appeal since it negates the need for the development of proxy estimation methods and their associated uncertainty and verification issues. Possible approaches are the use of satellite imagery and/or direct terrestrial measurements at paddock/farm scale throughout the country, scaled to provide a national emissions total. Satellite imagery is highly attractive since, in theory, it can provide continuous real time measurements of New Zealand's GHG footprint using an existing network of satellites. However, there are severe technical issues to be overcome. Firstly, the concentrations of N_2O and CH_4 are low (e.g. CH4 is < 2ppm) and, so far, attempts to pick up a CH_4 footprint have failed. Secondly, there is the issue of separating anthropogenic emissions (e.g. enteric fermentation) from natural sources of CH_4 (e.g. wetlands and volcanic activity). Thirdly, significant problems posed by cloud cover when using current technologies in NZ have yet to be overcome. Finally, although radar technologies may overcome some of the current problems, they are in their infancy and considerable development work is needed before their use can be considered. Similarly, although methods do exist to measure CH_4 and N_2O emissions at paddock/farm scale, they are highly dependent upon climatic conditions and so have large uncertainties associated with them. They are currently only used for short periods due to technical complexity, they need expensive monitoring equipment which limits their use to single sites, and at scales other than the paddock, and there is still an issue of separating anthropogenic from non-anthropogenic emission sources. In addition, even if a network of measurement sites could be established, emissions at these sites would have to be scaled in space and time to obtain a national emissions total. The group therefore unanimously rejected the concept of an agricultural inventory based on direct measurement of gaseous emissions at present.

Real time data	What categories of real time data might be gathered? The inability to obtain data was considered to be the major constraint to developing alternative inventory methodologies, particularly when there is a need to have, or at least be able to construct using proxy measures, a time series back to 1990. It was considered that climatic data (e.g. temperature and rainfall) did not provide a major constraint since considerable effort has already been expended on obtaining these data at fine spatial scales. Four principal categories of data needs were identified, and then considered in detail, in terms of their availability, at the different spatial scales defined above: • Animal numbers. • Animal productivity. • Herbage quality. • N fertilizer applications.	
	Animal numbers	
	Scale	*Availability.*
	LTA regions	Annual population figures available from statistics NZ. Error estimates available. Constructing a time series back to 1990 is possible although there are some missing years.
	LIC regions	Annual population figures available from LIC and can be obtained from StatsNZ. Error estimates may be available from StatsNZ. Stats NZ and published LIC data are annual figures but taken at different times of the year. StatsNZ are for June 30 populations whereas LIC are populations are at 'peak' milk. LIC data are for milking cows only whereas StatsNZ have a more comprehensive disaggregation of the population. Both LIC and DairyNZ have a full time series back to 1990, although changes in boundaries make some adjustments necessary for early years and there are missing years for StatsNZ. Error estimates not published by LIC but could perhaps be obtained from StatsNZ.
	Meat and Wool NZ farm types	MWNZ have data for annual populations and more detailed data for representative farm types which have

	geographic boundaries. Time series data can be constructed for these farm types. Some segments of the population do not fit into the farm types and so populations based on farm types do not account for the total beef and sheep populations. No error estimates are published.
LENZ	No direct figures available but could be obtained on an annual basis through modelling. StatsNZ mesh grids could possibly be used. Difficult to establish error estimates. Time series data can be constructed.
LUC	No direct figures available but could be obtained on an annual basis through modelling. StatsNZ mesh grids could possibly be used. Difficult to establish error estimates. Time series data can be constructed.
Rainfall and temperature zones	No direct figures available but could be obtained on an annual basis through modelling. StatsNZ mesh grids could possibly be used. Difficult to establish error estimates. Time series data can be constructed.
Soil type classification	No direct figures available but could be obtained on an annual basis through modelling. StatsNZ mesh grids could possibly be used. Difficult to establish error estimates. Time series data can be constructed.
Land classification by slope	No direct figures available but could be obtained on an annual basis through modelling. StatsNZ mesh grids could possibly be used. Difficult to establish error estimates. Time series data can be constructed.
Farm scale	Population data available by farm but issues of confidentiality. Not available for lifestyle blocks. Also calculation issues. Time series data can be constructed.
Catchment	No direct figures available but could be obtained on an annual basis through modelling. StatsNZ mesh grids could possibly be used. Difficult to establish error estimates. Time series data can be constructed.

Animal Productivity	
Scale	*Availability*
LTA regions	Unavailable.
LIC regions	Available for dairy only. Can construct a time series from 1990 although modelling approaches have to be used for early years.
Meat and Wool NZ farm types	Limited productivity data available. Constructing a time series very difficult if not impossible.
LENZ.	Unavailable.
LUC	Unavailable.
Rainfall and temperature	Unavailable.
Soil type	Unavailable.
Slope	Unavailable.
Farm	Unavailable.
Catchment	Unavailable.
Herbage Quality	
Scale	*Availability*
	None available at any of these scales at present and current estimates are based on samples taken from a small number of farms in a limited geographical set of locations and for a maximum of 1-2 years only. However, satellite imagery-based approaches may make it possible within the next couple of years to construct a time series (monthly resolution) of herbage quality values at fine spatial scales.
Fertiliser Application	
Scale	*Availability*
	Nitrogen fertiliser applications only are needed. Data only available as a total annual figure for NZ. Fertiliser companies possibly hold data that make spatial and temporal disaggregation possible but there are confidentiality issues involved in obtaining these data. StatsNZ may be able to provide data on N fertilizer applications.

4. Identification of assessment criteria for inventory methodologies

Following on from the initial discussion around issues which identified some "givens", an in-depth conversation took place to identify the criteria by which any potential methodology needs to be assessed. This resulted in the generation of an agreed set of assessment criteria. Each item on the list was then allocated a priority ranking from 1 (being the most important) to 3 (being the least important).

Table 2 Assessment criteria ranked by importance

Assessment Criterion	*Importance*
Meets reporting output requirements – can the methodology generate the data needed to allow completion of the current reporting output tables?	1
Compatible with 2006 guidelines (transparency, completeness, consistency, comparability, accuracy) – is the method able to comply with the international reporting guidelines? The latest guidelines are those published in 2006. Although they are not currently obligatory it is anticipated that they will become so at some future data.	1
Simplicity - can the inventory be constructed in an appropriate timeframe using an appropriate level of resources?	1
Ease of making projections – can the methodology be used to enable accurate predictions of future emissions?	1
Proximity to absolute values in each year – how accurately does the inventory method reflect the "true" emissions on an annual basis?	1
Ability to incorporate mitigation - is the method flexible enough to allow the incorporation of a diverse range of mitigation practices?	1
Availability and accuracy of data / verification and compliance – are good quality data available/collectable to underpin the chosen methodology?	1
Practicality & cost – are the costs of data collection and the ease of calculation reasonable?	1
Recognition of the weakest link – is the process transparent enough to allow for the quantification of the uncertainties at all stages of the calculation procedure so that the critical components can be identified?	1
Appropriate data capture and computation - can appropriate data be easily captured/modeled?	1
Meet the wider reporting requirements for NZ e.g., ETS & LCA – does the methodology have benefits that go beyond GHG inventory reporting needs?	2

Management of Kyoto accounts - does the methodology result in a change in New Zealand’s GHG liabilities?	2
Level of risk / predictability of liability – does the methodology result in more stable and predicable emissions estimates?	3
Ability to export to developing countries – could the method provide a template for other countries?	3
Scenario analysis - can the method be used to play “what if” games?	3

5. Possible future inventory methodologies

Following the detailed discussion of issues, summarised in Section 3 above, it was decided that there were three potential methodological approaches to consider. These were:

(a) A refinement of the current inventory structure using only currently available data.
(b) Moving to a product basis for the inventory.
(c) Moving to a farm basis for the inventory.

General discussion raised several points pertinent to all potential methodologies:

- International reporting requirements necessitate a need to demonstrate continuous improvement in the inventory but this should not be through huge efforts for small gains. A "change for change's sake" approach would be inappropriate.

- The inventory methodology should reflect reality as closely as possible, and the need for consistency in reporting requirements should not constrain the development of more accurate reporting methods. The methodology used should meet current and future needs and development should not be constrained by the need for the approaches used, and the emission estimates obtained, to align with those of the past.

- There is a need to determine what data are required rather than to take the approach that a methodology cannot be used because of a lack of data. The assessment criterion around data should therefore be based on how easy or difficult it would be to obtain data, as opposed to whether or not the data are already available.

Each potential inventory methodology was then discussed in terms of the issues identified and the criteria for assessing appropriateness, to derive a list of pros and cons for each alternative.

5.1 Adaptation of current inventory methodology

Consideration of potential changes to the current inventory methodology, in terms of the issues and assessment criteria, concluded that moving immediately to a more spatially disaggregated methodology is feasible and appropriate for some sectors.

A discussion on the most suitable scale and sources of regional data concluded that LENZ would not be workable due to the lack of appropriate data and the difficulty of acquiring these data in the future. Uncertainty would be high due to the need to model so much of the data required. LTA or LIC regions, on the other hand, would provide a scale at which real time data could be applied, although some modelling would be needed and possibly the addition of data from LENZ or LUC.

Moving to a regionally based methodology using the current calculation methodologies, would shift the N_2O inventory more towards a Tier 2 system (with elements of Tier 3) and further cement the CH_4 inventory as Tier 3. These changes would therefore represent an improvement on the current methodology, although this would need to be tested (especially the level of uncertainty) using real numbers. Such a methodology should better account for non-linear processes, and mitigation measures would be more accurately captured at the regional level. However, further consideration should be given to improving the accuracy of data collection.

Since regional productivity data only exists for dairy, the regional approach would only really make sense for this sector, at this time. For all other sectors data is either unavailable or would need to be modelled, giving rise to inaccuracies. Mechanistic models may help to inform the inventory in the future, but would most likely not be included in the inventory at present, due to their need for further development. Within each region, consideration needs to be given as to whether there are additional advantages to further disaggregation based upon soil and climatic factors.

A significant advantage of refining the current methodology, as opposed to moving to one based on different data sets, is that it does not require a substantial investment of time and resources in assembling new data. Instead, it makes better use of the existing data and adds little additional cost since the current national inventory software can be used in the calculations.

5.1.1 Feasibility of moving to a more complex formula for N_2O

The accurate estimation of N_2O emissions from NZ soils is difficult due to the complexity of the underlying biology and the availability of relevant data at appropriate scales. Even simple models suffer from a lack of good input data, for example N fertiliser input at a scale finer than a national annual total.

The two fundamental drivers of N_2O emissions are N availability and soil moisture levels. This means that even if N availability is known, emissions will vary greatly over time according to rainfall. Emissions profiles can vary by a factor of three or four from one year to the next despite relatively similar amounts of N availability since they are characterised by high emissions around rainfall events, especially if these are preceded by long dry spells. However, while obtaining data on rainfall and evaporation at a range of scales is quite straightforward, the key to accurately estimating emissions lies in refining our understanding of soil drainage functions, and the role of soil structure and other factors in contributing to drainage variability, combined with a knowledge of N inputs at the appropriate temporal and spatial scale.

While the desirability of moving to a more complex methodology for inventory calculation of N_2O was agreed, nervousness was expressed about the assumptions which would be required. Complex models are available, but there was general agreement that at this relatively early stage in the development of models appropriate for use in pastoral systems, and the need for confidence that any models used would be stable and durable for use in the future, adopting a mechanistic modelling approach was not appropriate.

It was therefore agreed that while simple models using the relationship between soil type and rainfall / evaporation could help to improve the inventory, further work was required before more sophisticated models might be used as a basis for inventory calculation. An immediate priority, therefore, was the development of simple relationships that could predict N_2O emissions using a combination of readily available soil, environmental and N input data. These simple models will need to be developed using a combination of empirical and mechanistic modelling approaches. Once these models are available disaggregation based on soil and environmental factors should be considered.

Table 3 Pros and cons of remaining with the current inventory methodology

PROS	*CONS*
Demonstrates continuous improvement.	Increased uncertainty through multiplication of errors from a larger number of inputs. This is a problem with any disaggregated approach.
Better able to capture mitigation effects. E.g. DCD is used in high productivity areas, and as reduction in emissions is calculated as a proportion of the non-DCD emissions, the mitigation effect is reduced when a national approach is adopted.	Misalignment of LIC and LTA regions meaning that some population modelling is necessary to align LTA populations coming from Stats NZ with the LIC regions.
More accurate – allows for regional differences in performance, timing of calving, breeds used etc to be incorporated.	Fertiliser data only available as a national figure although Stats NZ do have fertiliser input data and it may be possible to use these data to obtain a regional split.
Relates better to other efforts such as ETS, tech transfer etc.	No wider use other than TLAs.
Better management of Kyoto liabilities – regional differences in productivity etc and the use of non-linear models means that there is a danger that the national approach over/underestimates Kyoto liabilities.	
Provides a platform for future refinement / development such as bringing in mechanistic approaches – further disaggregation possible for N_2O.	
Makes better use existing data – data are available at this scale and should be used if possible.	

Adds little additional cost since the current national inventory software can be used in the calculations.	

5.2 Inventory methodology based on emissions by product type

The concept behind this proposal is that representative farms could be used to calculate emissions for each type of product and the inventory compiled by multiplying up by the amount of product produced. Emissions would need to be estimated at a local scale using population, productivity, soil and environmental data, but rather than being scaled by animal population and/or farm type, the scaling would simply be based on the quantity of product produced.
This would allow comparisons by farm and region, as well as producing a national figure, and could be very useful in terms of international trade through alignment with the ETS and an ability to demonstrate low production emissions to consumers.
In terms of the calculations, there would no longer be a need to know the total number of animals, though this figure would still be required for the national return. This would mean that there was no longer a need for population models, since actual numbers would be used at the farm level, and there could be a consequent reduction in complexity and improvement in accuracy. On the other hand, uncertainty would be introduced in the process of scaling up from representative farms and weighting by farm type. Problems could be encountered with the incorporation of mitigation which may not be taking place on monitor farms but might be prevalent elsewhere.

The absolute importance of ensuring that monitor farms are truly representative was stressed, and that farms which are once deemed to be representative remain so over time. The number of representative farms required to provide accuracy was considered to be in the region of 500, and this also highlighted issues of complexity, cost, availability and accuracy of data. Issues around appropriate information capture and computation were also considered important.

Alignment with the ETS was thought to be most feasible through Fonterra for dairy, but uncertainty was expressed over which products could be used for sheep and beef – emissions per carcass, emissions per unit of wool? The need to collect information from farmers raised issues of unreliability.

The adoption of this system was considered to be quite a radical departure from the current methodology, but one which was not inconsistent with the 2006 guidelines and which could have some real merits, including being a Tier 3 system. Relating figures back to 1990 base level would present some difficulties, but on the other hand, once established, this methodology could be responsive to any new production systems put in place.

Table 4 Pros and cons of moving to an inventory methodology based on product type.

PROS	*CONS*
Simplicity.	Difficulty with product differentiation e.g. meat vs. wool, velvet vs. venison, milk vs. meat.
Alignment with ETS.	Ability to capture mitigation measures in the figures.
More representative than the current system.	Farms can never be completely representative so there will always be some inaccuracy in the figures.
Emissions sensitive.	Scaling introduces uncertainty.
Better information on emissions sensitive to local inputs and conditions.	Farms may cease to be representative over time.
Flexibility / future-proofing.	If new system gave a different answer we would need to understand the reasons for that difference.
Responsive to “real” events.	Data vulnerability if not in government control – reliance on farmers to provide the information.
Ability to capture unique circumstances.	Existing network of farms may not provide the ideal data set.
Have an existing network of farms to work with.	Considerable time and resources required to assemble the data.

5.3 Inventory methodology based on emissions by farm type

The methodology which would be adopted in this approach is very similar to that described in 5.2 above, in that data would be collected at the farm level, although scaling to national emissions would be based on the number of farms, and/or the proportion of the animal population represented by each farm type. Farms could be selected according to geography as well as farm type, with consideration given to looking at farm types representative of the regions.

Again, this approach is structurally different from the current inventory because it is not based on population. Instead, it is based on farms at a specific location with a specific population, and is therefore a more bottom-up approach. Scaling could be via the estimation of emissions per animal in each “region” and scaled by the population in each “region”. “Region” could be defined by a combination of farming type and soil/environmental conditions. Alternatively, the ANZIC code is a UN recognised way of categorising by farm type and this could be a basis for aggregating up as an alternative to using population data. Obtaining productivity data presents a formidable challenge since these are not routinely collected at present. However, representative farms are monitored by MAF and the dairy and beef/sheep sectors, and it may be possible to add these data to the data currently collected on a routine basis.

While this methodology would be more complex than the current methodology, the output data would simpler to understand and give much more helpful information in a wider context. The approach would also be likely to be popular with the farming community as local data based on the unit of production (the farm) has more personal relevance. In addition, it would meet all reporting requirements and be compatible with the IPCC guidelines. Once again however, obtaining activity data would be more costly and potentially problematic, and accounting accurately for mitigation could present difficulties if the farms were not representative of those adopting mitigation approaches. Ensuring that farms are truly representative in space and time is a significant challenge.

This approach also has the advantage of alignment with a farm based point of obligation in an ETS scheme. Data from farms in the scheme could be used to ensure that sample farms are representative over time.

Table 5 Pros and cons of moving to an inventory methodology based on farm type

PROS	*CONS*
Direct farm benefit through relevance to farmers.	How do basic structures interact with mechanistic models to improve complexity / accuracy of calculations?
Alignment to other efforts e.g. Overseer.	How well is it possible to capture mitigation measures in the figures? – issue of representative farms in space and time
Ultimately farmers will need to drive emissions down – relevance of the accounting methodology to the farm emissions will assist.	Farms can never be completely representative so there are issues of accuracy and uncertainty.
Activity data should be more representative if it is actually being collected on farms.	Scaling not straightforward and uncertainty at national level may be unacceptably high.
Better information on emissions sensitive to local inputs and conditions.	Farms may cease to be representative over time.
Could scale according to the number of animals or farm type, so could use some of the same data as the current system.	Consistency with previous emissions estimates - if the new system gave a different answer we would need to understand the reasons for that difference.
Flexibility / future-proofing.	Problems of allocating a farm type to a certain percentage of farms.
Responsive to “real” events.	Data vulnerable if not in government control and the reliance on farmers to provide the information.
Ability to capture unique circumstances.	Existing network of farms may not provide the ideal data set – difficulty of constructing an historical time series.

Have an existing network of farms to work with.	Considerable time and resources required to assemble the data.

6. Industry perspectives

Following the workshop, representatives of industry were interviewed to determine their views, and to gain an in-depth understanding of their approach to data collection and the availability / usefulness of data collected for inventory purposes.

6.1 Consultation with Meat and Wool NZ (MWNZ)

6.1.1 General approach to data collection

The primary purpose of MWNZ data collection from its survey farms is to enable the accurate prediction of sheep meat and wool production. MWNZ currently has a team of 13 people who visit approximately 45 farms each to collect the data. In total, 550 farms are surveyed, equating to approximately 4.5% of all beef and sheep farms. The farms are divided into 8 farm "types" which can also be assigned to very broad geographic regions. Farms are selected by government statisticians, with populations segregated into 1000 stock unit intervals, containing an average of 4.5% of farms in each interval. However, regional farm type variability influences sampling percentages; so that those areas with a high degree of similarity in farm type have a reduced sample size and vice versa. The survey aims to have a margin of error of 3% for population size, estimated in terms of livestock units.

Since farms are categorised by broad regions and production type, it is possible to look at farm type within a region, but uncertainties are "significantly" higher although not quantified.

The aim is to turnover 12-15% of farms each year to ensure that the sample remains representative, while at the same time ensuring that there is not too much variation between years. Annual turnover is currently running at about 18%. The MWNZ survey is standardised to a June financial year, although 25% of farms have a March balance date.

Farm visits are spread throughout the year, though sampling intensity is greatest from March to June. A visit consists of about four hours with a farmer during which financial records, GST dockets, tax accounts etc are examined to obtain a full reconciliation of stock numbers for the year. However, no attempt is made to reconcile these with census data which also has a June date.

MWNZ also has a range of monitor farms which are sampled on a more intensive basis for extension and tech transfer activities. These are not selected in a systematic way and are therefore not intended to provide a representative sample of the industry.

6.1.2 Data collected

Population data
There is full reconciliation of opening and closing, and around sales, purchase and deaths. Animals are classified by age, sex etc, and so a detailed categorisation of the total farm population at a monthly time step can be constructed if required, although only end of year values are published at present.

The timing of births are modelled from a knowledge of when rams/bulls are introduced and the percentage held to service in each reproductive cycle. The timing of sales can be obtained from sale dockets while the timing of deaths is modelled.

Productivity data
The weight of growing animals at sale is obtained from sales dockets, generally in the form of carcass weight at slaughter. Some farms record the weight of store animals at sale and, in some cases, it is possible to infer an approximate weight based on timing of the sale and the price received. Cattle present greater difficulties because of the increased number of categories of animals.

The weights of breeding stock are not recorded and default values at opening and closing are assumed using standard average weights for each farm type. There is no systematic adjustment of these standard weights although they are adjusted periodically.

Breed information is collected on each survey farm as are wool sales data.

Fertiliser purchases are recorded but the timing of their application is not.

6.1.3 Data availability and accessibility

Population data is available pre 1990, but productivity data is far less comprehensive since it was not collected between 1991 and 2006/7. Lambing/calving percentage and wool yield are, however, available for all years.

MWNZ has a purpose-written and easily accessed database using standard routines for high demand data. Some types of data are more difficult to access than others however, e.g. meat production by month. If data were required other than that already assembled from the data collected, routines would need to be purpose written. This would incur a short term capital cost but lower ongoing costs.

Confidentiality issues mean that individual farm data is not available, only aggregate data containing region and farm type.

6.1.4 Planned changes to data collected

There are currently no firm plans to change the data collected in future, but MWNZ is open to changes should they be required. For example, discussions are already taking place around the desirability and feasibility of collecting more data on environmental performance indicators.

There are little productivity data available at present and no plans to change this. The 13 managers who survey farms (45 each) have a limited amount of time and data are only added if there are significant benefits. This is done as a special exercise rather than a routine addition to the survey. Cost and time are the biggest barriers to collecting further data.

6.1.5 MWNZ views on a farm based inventory approach

MWNZ were of the view that moving to a farm based inventory methodology would improve the usefulness and relevance of the inventory to farmers, and that the data could form the basis of extension activities. They expressed the view that ultimately, if there is to be a price on carbon emissions, then there will need to be a farm based point of obligation. In the long run they believe that this will mean moving to a bottom-up inventory methodology, but that the current suggestion could represent a useful transition step until issues around cost and time can be overcome.

7. Research priorities

With regard to N_2O there was strong agreement that the calculations of emissions should better reflect the multiplicity of factors that influence emissions in practice. Therefore, in the longer term, soil and environmental factors should be included in the national inventory calculations. The identified need is for simple robust algorithms that can give better real time predictions of N_2O from a range of easily available data. This research would involve empirical studies integrated with the design and use of mechanistic, robust, process-based models, coupled with spatial and temporal datasets.

Research priorities for CH_4 were not discussed in detail, although the general inadequacy of using a constant methane yield (CH_4/kg DMI) value was recognised. A priority for CH_4 inventory research is therefore to obtain more robust and sensitive predictors of the relationships between CH_4 output and the range of diets, animal species, and sub-classes of animal species, found in New Zealand.

8. Recommendations

The conclusions were that three realistic options exist for future inventory methodologies:

(a) An adaptation of the current methodology based on regional data
(b) Methodology based on emissions by product type
(c) A methodology based on emissions by farm type

There are pros and cons to the adoption of each of these methodologies, in terms of data availability, cost, complexity, accuracy and so on. In choosing the most appropriate way forward, the ministry will need to decide the extent to which it wishes to invest in methodological sophistication for the sake of ongoing improvement and accuracy.

Option 1 presents a relatively simple, low cost option for improving the inventory and could be adopted with immediate effect. Option 2 would be an innovative departure from the current methodology, should increase accuracy and have the potentially significant advantage of alignment with the Emissions Trading Scheme. Option 3 should also increase accuracy and have the real advantage of being relevant to farmers on whom we will be reliant for future emissions reductions, and have the potentially significant advantage of alignment with the Emissions Trading Scheme. However, options 2 and 3 are more complex and costly, and there would be issues to be resolved around data collection and computation. Option 3 has the potential advantage of being the first step in examining how a bottom-up farm based inventory scheme, such as that proposed in the long run for an ETS scheme, would align with the current top-down approach. An important question is whether or not a bottom–up approach would yield different answers to a top-down approach with regard to the assignment of liabilities and credits in an ETS system.

The following three recommendations are made:

1. An adaptation of the current methodology, as outlined in this report (an immediate move to a regional dairy inventory), is adopted in compiling the 2009 inventory.

2. Further work is conducted on the feasibility of using Options 2 and 3 for future inventories.

3. For options 2 and 3, a pilot study should be undertaken for 1990 and the current year (2007/8) so that an assessment can be made of the alignment of any new emissions estimates (obtained using these bottom-up approaches) with existing estimates. These pilot studies should concentrate on the beef and sheep sectors in the first instances as they can then identify the data availability and accessibility. A key component of these pilot studies should be a preliminary assessments of the uncertainties in these alternative methodologies.