Ministry for Primary Industries
Manatū Ahu Matua

MPI POLICY AND TRADE
Agricultural Inventory Advisory Panel Meeting
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HILL COUNTRY – DIRECT N_2O FROM EXCRETA (EF_3)

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Main Purpose: ☑ Decide ☑ Discuss ☐ Note

Report Contents

Purpose of this Report

1. Seek approval from the Agricultural Inventory Advisory Panel to:

    - Include emission factors for direct nitrous oxide emissions from animal excreta (EF_3) reflecting stock type and the effects of slope
    - Implement a methodology for estimating emissions from direct N_2O from livestock excreta on hill country in New Zealand (EF_3).

2. Provide information to address the issues raised by the Panel on the hill country research from the 2014 Agricultural Advisory Panel meeting. The issues raised by the Agricultural Inventory Panel meeting are as follows:

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a. Since the last Panel meeting, the Giltrap et al. (2014) technical report has been published in a peer-reviewed scientific journal. Please refer to the attached journal article, Saggar et al. (2015).

b. Further clarification on the assumptions used for urine/dung deposition that are utilized by the Giltrap et al. (2014) technical report and the Saggar et al. (2015) journal article (see also the supplemental material in relation to this).

c. Further clarification on the data analysis methodology utilized in the Kelliher et al. (2014) journal article (also see the attached supplemental materials in relation to this).

d. Review the Saggar et al. (2015) journal article to assess the suitability of the research for inclusion into the inventory. The review will take into consideration the information, assumptions, and inputs presented in the Saggar et al. (2015) article to determine if these can be applied to our inventory in a way that is acceptable for a national inventory. The review will be carried out Dr. Tom Misselbrook from Rothamsted Research, UK.

Background

3. New Zealand has an obligation under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol to report anthropogenic greenhouse gas emissions and removals every year. Emissions are estimated and reported in the annual submission of the National Inventory Report submitted to the UNFCCC. This reporting requirement is also legislated by the New Zealand Climate Change Response Act (2002).

4. Any future commitments taken by New Zealand to reduce greenhouse gas emissions may have a financial cost based on emissions reported in the National Inventory Report. Therefore reported emissions and removals need to be as accurate as possible. New Zealand has a long-standing research program in estimating country-specific emission factors to aid in the improvement of reported emissions and removals from the land-based sectors.

5. Reporting must meet the recommendations in the guidelines provided by the Intergovernmental Panel on Climate Change (IPCC)[i]. Improvements are encouraged to take account of national circumstances beyond the default methodology and emission factors that are recommended in the 2006 IPCC Guidelines, and need to be well-documented and transparent.

Current Inventory

6. The current EF_3 values for direct nitrous oxide emissions from excreta from livestock grazing on pasture are 0.25 per cent for nitrogen in dung and 1.00 per cent for nitrogen in urine for non-dairy cattle, sheep and deer. These values are applied irrespective of livestock type, land use or slope, which can influence direct nitrous oxide emissions from grazing livestock excreta. As nearly half of New Zealand's national livestock grazes hill country pasture, it was recognised that the current emission factors may overestimate nitrous oxide emissions.

Last year's Panel recommendation

7. The Agricultural Inventory Advisory Panel recommended against the "Hill Country – Direct N_2O from Excreta (EF_3)" research being incorporated into NZ's agricultural greenhouse gas inventory at the 2014 meeting. It was noted that this research could be considered again at the 2015 Panel meeting provided

that this research was published in a peer-reviewed scientific journal and that the Panel's concerns were addressed.

Proposed Improvement to the Inventory

8. Following recent studies (Kelliher et al., 2014; Giltrap et al., 2014; Saggar et al., 2015), it is proposed that the rates for direct nitrous oxide from livestock excreta deposited in pasture are updated to:

   a. delineate between non-dairy cattle (i.e. beef cattle), sheep and deer livestock categories

   b. allow the effect of local slope to be factored into the calculation.

9. Giltrap et al. (2014) and/or Saggar et al. (2015) developed a methodology to provide national estimates of N_2O emissions from sheep, beef cattle and deer for both dung and urine across different slope classes. New Zealand Beef + Lamb Economic Survey data were used to calculate the distribution of slope classes across farm types, which were scaled against the national livestock population data from Statistics NZ Agricultural Production Survey to derive dung and urine N for use in the Greenhouse gas Inventory model. To estimate total emissions, a nutrient transfer model estimated excretal N depositions on low, medium and steep slopes, which were then multiplied by values derived from Kelliher et al. (2014) (see table 1).

Clarifications

Clarification of the assumptions for dung and urine deposition on hill country slopes from Giltrap et al. (2014) and/or Saggar et al. (2015)

10. The allocation of dung and urine to the different slope classes is regulated by animal grazing, resting and excretion patterns in hill country and is not simply in proportion to the relative area of each slope class. The values used for dung and urine allocation are based on the measurements from two Hill Country sites i) "Ballantrae" Hill Country Research Station of Grassland Division, DSIR and ii) Whatawhata Research Centre, MAFTech and described/referred to in Saggar et al. (1990 a, b), Rowarth (1987) and Rowarth et al. (1988). Further information on the deposition of urine/dung from Professor Saggar can be found in Appendix 3.

11. Table 1 provides the direct nitrous oxide emission factors applied to the different slope classes for urine and dung deposition from beef, sheep and deer livestock along with the reason for the proposed values.

Table 1: Direct nitrous oxide emission factors (%) for low, medium and high sloping hill country lands used in Giltrap et al. (2014) and/or Saggar et al. (2015).

Animal and excreta type	**Low slope**	**Reason**	**Medium slope**	**Reason**	**High slope**	**Reason**
Beef cattle urine	0.99	Same value proposed for low slopes for beef cattle urine in Kelliher et al. (2014)	0.32	Same value proposed for medium slopes for beef cattle urine in Kelliher et al. (2014)	0.32*	This is the same urine value determined for medium slopes in Kelliher et al. (2014)
Beef cattle dung	0.21	Same value proposed for low slopes for beef cattle dung in Kelliher et al. (2014)	0.06	Same value proposed for medium slopes for beef cattle dung in Kelliher et al. (2014)	0.06*	This is the same value determined from medium slopes for beef cattle dung in Kelliher et al. (2014)
Deer urine	0.99*	This is the largest of the beef and sheep urine values determined for low slopes in Kelliher et al. (2014)	0.32*	This is the largest of the beef and sheep urine values determined for medium slopes in Kelliher et al. (2014)	0.32*	This is the same value determined for deer urine from medium slopes in Kelliher et al. (2014)
Deer dung	0.21*	This is the largest of the beef and sheep dung values determined for low slopes in Kelliher et al. (2014)	0.06*	This is the largest of the beef and sheep dung values determined for medium slopes in Kelliher et al. (2014)	0.06*	This is the beef cattle dung value determined from medium slopes in Kelliher et al. (2014)
Sheep urine	0.55#	Same value proposed for lowlands for sheep urine in Kelliher et al. (2014).	0.16	Same value proposed for medium slopes for sheep urine in Kelliher et al. (2014)	0.16*	This is the sheep urine value determined from medium slopes in Kelliher et al. (2014)
Sheep dung	0.11	Same value proposed for low slopes for sheep dung in Kelliher et al. (2014)	0.11*	This is the value proposed for low slopes for sheep dung in Kelliher et al. (2014)	0.11*	This is the sheep dung value determined from low slopes in Kelliher et al. (2014)

* These represent conservative-based figures for use in each category as this data is not known. In the case for the higher slope values the approach was to use medium slope values, although it is very likely that as terrain slope increases the emission factors for both urine and dung decrease (D. Giltrap, personnel communication, 2015). For deer urine and dung emission factors, beef cattle values have been used across all slope classes as it is unlikely that the emission factors for deer excreta would be larger than those for urine and dung from beef cattle (D. Giltrap, personnel communication, 2015). For medium and high sloping lands for sheep dung, low slope emission factors were used from Kelliher et al. (2014).
# The sheep urine emission factor used for low sloping lands is based on a conservative value taken from the highest value between the lowland and low slope emission factors proposed by Kelliher et al. (2014).

Clarification on the data analysis methodology utilised in Kelliher et al. (2014)

12. Kelliher et al. (2014) performed a meta-analysis of 185 field trial data obtained between 11 May 2000 and 31 January 2013 to estimate mean emission factor (EF) values for direct nitrous oxide emissions from nitrogen (excreta and urea) applied to pastoral soils in New Zealand delineated by livestock type and slope (table 2).

Table 2: Best linear unbiased predictors for direct N_2O emission factors (%, mean ± standard error, sample size (n)) of the nitrogen sources given for dairy, beef, sheep and urea fertilizer. Taken from Kelliher et al. (2014).

N source	Lowland	Hill country/low slope	Hill country/medium slope
Dairy cattle urine	1.16 +/- 0.20, 55	0.84 +/- 0.20, 16	
Dairy cattle dung	0.23 +/- 0.05, 20	0.20 +/- 0.07, 4	
Beef cattle urine		0.99 +/- 0.37, 4	0.32 +/- 0.12, 4
Beef cattle dung		0.21 +/- 0.06, 12	0.06 +/- 0.02, 4
Sheep urine	0.55 +/- 0.19, 4	0.40 +/- 0.10, 12	0.16 +/- 0.05, 8
Sheep dung	0.08 +/- 0.02, 12	0.11 +/- 0.03, 8	
Urea fertilizer	0.48 +/- 0.13, 22		

13. The meta-analysis included seven nitrogen sources across three different types of topography (i.e. lowland, hill country/low slope and hill country/medium slope) in order to estimate the N_2O EF's from nitrogen (N) sources applied to pastoral soils.

14. Kelliher et al. (2014) analysed the field trail data by calculating best linear unbiased predictors (BLUPs) through utilizing a restricted maximum likelihood method. Mean EF values for each N source were then estimated. The EF values from the N sources could then be considered as if the data were actually from the same proportion of lowland to hill country sites as the six other nitrogen sources, keeping in mind few data were available from trials conducted on medium slopes of hill country sites. The meta-analysis also accounted for the proportions of summer to autumn trials and other variables which are described in further detail in Kelliher et al (2014). Otherwise, fair comparisons cannot be performed, as 'raw' averages will partly reflect the different proportions of data collected from hill versus lowland, summer versus autumn etc. An example and further clarification on this method is given in Appendix 5.

Effect of changes

15. The methodology from Giltrap et al. (2014) and/or Saggar et al. (2015) has been applied to 1990-2012 emissions data to demonstrate the overall effect of implementing this methodology into New Zealand's agricultural greenhouse gas inventory. The overall result will be a reduction of nitrous oxide emissions by approximately 15.4 per cent, or 7,473 kt CO_2-e during the first commitment period (2008 to 2012) (table 3). Note that this recalculation will not affect the estimate of emissions that has been published for the first commitment period of the Kyoto Protocol, because this estimate was confirmed and accepted by the UNFCCC during the annual review of national inventories during September 2014.

Table 3: Impact of new EF_3 emission factors on New Zealand's total greenhouse gas emissions (1990-2012) using IPCC Fourth Assessment Report (AR4) Global Warming Potentials.

Year	Inventory nitrous oxide emissions (ktN_2O)	With revised EF_3 emission factors (ktN_2O)	Inventory carbon dioxide equivalent emissions ($ktCO_2$-e)	With revised EF_3 emission factors ($ktCO_2$-e)	Difference ($ktCO_2$-e)	% difference
1990	25.5	18.8	7,593	5,593	-2,000	-26.3%
1991	25.8	19.1	7,677	5,705	-1,972	-25.7%
1992	25.5	19.2	7,610	5,716	-1,894	-24.9%
1993	26.2	20.0	7,822	5,958	-1,864	-23.8%
1994	27.3	20.9	8,145	6,231	-1,914	-23.5%
1995	28.2	21.9	8,399	6,522	-1,877	-22.3%
1996	28.5	22.2	8,495	6,624	-1,871	-22.0%
1997	29.0	22.5	8,642	6,715	-1,927	-22.3%
1998	28.7	22.5	8,544	6,691	-1,853	-21.7%
1999	29.2	22.9	8,692	6,827	-1,865	-21.5%
2000	30.3	23.9	9,035	7,132	-1,903	-21.1%
2001	31.6	25.5	9,405	7,608	-1,798	-19.1%
2002	32.8	27.0	9,766	8,038	-1,728	-17.7%
2003	33.8	27.8	10,072	8,299	-1,773	-17.6%
2004	34.0	28.1	10,138	8,365	-1,773	-17.5%
2005	34.3	28.2	10,236	8,414	-1,822	-17.8%
2006	33.9	27.9	10,116	8,305	-1,811	-17.9%
2007	32.6	26.9	9,729	8,019	-1,710	-17.6%
2008	31.9	26.7	9,509	7,957	-1,552	-16.3%
2009	31.3	26.2	9,341	7,821	-1,520	-16.3%
2010	32.4	27.4	9,649	8,172	-1,477	-15.3%
2011	33.3	28.4	9,919	8,471	-1,449	-14.6%
2012	34.0	29.1	10,140	8,665	-1,475	-14.5%
Total for 2008 to 2012	162.9	137.9	48,558	41,085	-7,473	-15.4%

Reviewer comments in relation to the Saggar et al. (2015) journal article

16. Please note that the the information, assumptions, and inputs presented in the Saggar et al. (2015) article will be reviewed by Dr. Tom Misselbrook, from Rothamsted Research, UK. His review commentary will be sent to the Panel once it is received and will be tabled at the Agricultural Inventory Advisory Panel meeting. This is in addition to the previous review reports completed by Professor Rowarth and Dr. Tillman which assessed the scientific robustness of the Saggar et al. (2015) journal article. These earlier reviews are given in Appendix 7.

17. Dr. Misselbrook will complete the standard Inventory review form for the Ag Advisory Panel meeting scheduled on 1 December 2015.

18. Therefore, we request that the Agricultural Inventory Advisory Panel take Dr. Tom Misselbrook's review report (when received) under consideration along with the additional clarification on the issues provided in this briefing when discussing whether the methodology can be incorporated into the Inventory.

Uncertainty in estimates

19. The effects of the new values on the level of uncertainty in the inventory have not been quantified. However, Table 1 provides one standard deviation about each of the estimates. The uncertainty estimates in the present Inventory chapter for N_2O from agricultural soils would need to be updated accordingly.

Recommendations

It is recommended that the Agricultural Inventory Advisory Panel:

20. ***Agree*** *that the values for the EF3 emission factor proposed in Table 1 in this briefing paper and taken from Saggar et al. (2015) may be incorporated into future Inventory calculations*

Agree / not agreed

21. ***Agree*** *that the methodology for estimating N_2O emissions from excreta from livestock grazing on pasture in hill country provided by Saggar et al. (2015) can be incorporated into the Agriculture Greenhouse Gas Inventory model.*

Agree / not agreed

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Approved/ Not Approved/ Approved as Amended

Gerald Rys
Science and Skills Policy/Resource Information & Analysis
Chair Agricultural Inventory Panel

Date

[i] 2000 IPCC Good Practice guidelines and 2006 IPCC guidelines