Ministry for Primary Industries
Manatū Ahu Matua

MPI POLICY AND TRADE
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IMPROVEMENTS AND CORRECTIONS TO INVENTORY MODEL

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Main Purpose: ☐ Decide ☑ Discuss ☑ Note

Purpose of this paper

1. To provide information on the improvements and corrections implemented in the agriculture inventory model (AIM) for the most recent inventory[1] submission:

   a. Correction – calculating the amount of nitrogen retained in wool.

2. To provide information on the improvements and corrections planned for next year's inventory submission:

   a. Improvements and corrections to population models.

   b. Improving the methodology used to estimate the areas of barley, oat and wheat crops burned.

3. Attached to this paper are the reports:

   a. Rollo, M, 2016 (unpublished) *Corrections to the calculation of Nitrogen retained in wool*.

   b. Rollo, M, 2017 (unpublished) *Error in calculation of sheep populations for class Mature breeding ewes.*

Background

4. Under the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines on annual greenhouse gas inventories, countries are required to report in the National Inventory Report (NIR) on any changes in emissions estimates due to the correction of errors[2]. This reporting generally involves:

   a. An explanation of the error, and;

[1] 2017 (1990-2015) Greenhouse gas inventory published by MfE
[2] http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf#page=2 paragraph 45

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b. The impact of the error (and its subsequent correction) on emissions estimates, for all reporting years in the time series.

5. During the compilation of the 2017 (1990-2015) NIR, two errors were found and corrected. These errors were discussed in the NIR[3] and are mentioned below:

   a. The nitrogen excretion (N_{ex}) emission factor for alpaca. The correction of this error had an insignificant effect on emissions estimates and is not discussed further in this document, and;

   b. The calculation used to estimate the amount of nitrogen retained by sheep in the production of wool. The correction of this error led to a 770 kt CO2-e (2.0 per cent) decrease in estimated agricultural emissions for 2015.

6. The identification of these errors (particularly the error identified in 5b) highlighted the need for a more thorough review of the AIM, in order to confirm that the equations and emission factors are correct. As part of this, the following actions were undertaken or are being completed:

   a. Mike Rollo (AgResearch) reviewed whether the equations outlined in the inventory methodology document[4] are consistent with the equations in the AIM code.

   b. The inventory team at MPI are in the process of revising and improving the inventory methodology document, with the aim of making it more readable and comprehensive. This revision (still in progress) has uncovered some errors and inconsistencies in the equations used to estimate monthly populations for different species and classes.

   c. AgResearch have been commissioned to document the equations and parameters used to calculate liveweight and liveweight gain in the AIM. This will lead to a project which will evaluate these equations and parameters and provide recommendations as to how they could be improved.

7. Since the publication of the 2017 (1990-2015) NIR further potential errors or inconsistencies have been identified through the ongoing revision of the methodology document. We intend to resolve these errors for the publication of next year's NIR:

   a. The equations used to estimate monthly populations for different species and classes (for example, mature breeding ewes, lambs, breeding bulls).

   b. The apportioning of crop-burning area between barley, oat and wheat crops.

The items noted in 5b, 7a, and 7b are discussed further in the sections below.

[3] New Zealand's Greenhouse Gas Inventory 1990–2015 http://www.mfe.govt.nz/sites/default/files/media/Climate%20Change/FINAL%20GHG%20inventory%20-%2025%20May.pdf, See section 5.5.5, page 194, and section 10.1.3, page 343.

[4] Detailed methodologies for agricultural greenhouse gas emission calculation, version 3, (2016). Ministry for Primary Industries http://www.mpi.govt.nz/dmsdocument/13906-detailed-methodologies-for-agricultural-greenhouse-gas-emission-calculation

Nitrogen retained in wool

8. Part of the nitrogen taken in by sheep through pasture is retained for the growth of wool, and this is used to help estimate emissions from the *Agricultural Soils* category of the inventory. The daily amount of nitrogen retained through wool production can be calculated using the equations below.

Nitrogen retained in wool produced by sheep:

$$N_{wool} = Wool_{sheep,daily} \times wool_{Ncontent}$$

Where:

N_{wool} = Amount of nitrogen retained in wool per animal (kg of nitrogen per day)
$Wool_{sheep,daily}$ = Amount of wool produced per adult sheep per day (kg)
$Wool_{Ncontent}$ = Nitrogen content of wool (assumed to be 13.4%)

The amount of nitrogen retained in wool is used to help calculate nitrogen excretion, which is ultimately used to estimate nitrous oxide emissions

Nitrogen excretion for sheep (Equation x):

$$N_{ex} = N_i - (N_m + N_{lwg} + N_{wool})$$

Where:

N_{ex} = Nitrogen excretion per animal (kilograms of nitrogen per day)
N_i = Nitrogen intake per animal (kg N/day)
N_{rm} = nitrogen retained in milk per animal (kg N/day)
N_{lwg} = nitrogen retained in live weight gain per animal (kg N/day)

9. In the second half of 2016, Landcare Research noted (as part of an unrelated project) a potential error in the calculation of N_{wool}. Further investigation by AgReseach confirmed that a formula used to calculate the amount of nitrogen retained in wool was not implemented properly in previous versions of the inventory, causing the amount of nitrogen retained in wool to be calculated as close to zero.

10. This error had been present in the model for a number of years. More technical details on the error and its correction are in the attached document *Corrections to the calculation of Nitrogen retained in wool.* The error was corrected in the submission of the 2017 (1990-2015) NIR.

11. The correction of this error had a significant impact on emissions estimates. Due to this correction, estimated emissions from *Agricultural Soils* fell by 23.6 per cent in 1990 and 8.9 per cent in 2015, compared to emissions estimates in the uncorrected AIM (see table below). The large fall in sheep population between 1990 and 2015 (see figure 5.1.3.b) helps explain the difference between the 1990 change and the 2015 change.

Table 1: Comparison of current and previous emissions estimates before and after nitrogen wool correction, 1990 to 2015

Emissions (kt CO2-e)		1990	2015	Change in emission outputs between 1990 and 2015 (kt CO_2-e)	Percentage change in emission outputs between 1990 and 2015
Total emissions from *Agricultural soils* (kt CO_2-e)	2017 (1990-2015) emissions estimate *without* nitrogen wool correction	6,863.1	8,687.4	1,824.2	26.6%
	2017 (1990-2015) emissions estimate *with* nitrogen wool correction	5,241.2	7,917.4	2,676.2	51.1%
	Difference in emission estimates compared to current inventory	-1,621.9	-770.0	852.0	
	Percentage difference in emission estimates	-23.6%	-8.9%		
Total emissions from Agriculture (kt CO_2-e)	2017 (1990-2015) emissions estimate *without* nitrogen wool correction	34,744.9	39,189.6	4,444.7	12.8%
	2017 (1990-2015) emissions estimate *with* nitrogen wool correction	33,122.9	38,419.6	5,296.7	16.0%
	Difference in emission estimates compared to current inventory	-1,621.9	-770.0	852.0	
	Percentage difference in emission estimates	-4.9%	-2.0%		

12. The identification of this error and the effects of its correction on emissions estimates was discussed in the 2017 (1990-2015) NIR[5]. During the most recent inventory review by the UNFCCC the expert review team (ERT) did not query the correction.

13. The scale of this error and the effect of its correction on emissions estimates highlights the need for improved transparency in the AIM and its associated methodology and science. The inventory team is currently doing this by undertaking the actions listed in paragraph 7.

[5] New Zealand's Greenhouse Gas Inventory 1990–2015 http://www.mfe.govt.nz/sites/default/files/media/Climate%20Change/FINAL%20GHG%20inventory%20-%2025%20May.pdf See section 5.5.5, page 194, and section 10.1.3, page 343.

Planned corrections to population model

14. As stated in the previous section, a population model is used to calculate monthly populations for the major livestock species (dairy cattle, beef cattle, sheep and deer) in order to reflect the natural variation in livestock populations that occur throughout the year. This model was developed in 2003 (Clark, Brooks & Walcroft)[6], and was modified following recommendations from the 2011 Agricultural Inventory Advisory Panel meeting.

15. Some of the rules governing the population model have been briefly outlined by Clark (2008)[7], but as part of a focus on transparency, the inventory team has, in the past year, documented in full the equations and parameters used to estimate the monthly populations for all 29 of the animal species classes used in the AIM. These population estimates are fundamental for calculating livestock emissions.

16. During this documentation, some potential errors in have been found in the population calculations of some animal classes such as:

    a. Dairy breeding bulls.
    b. Beef slaughter steers 1-2.
    c. Beef breeding bulls mixed age.
    d. Sheep breeding mature ewes.

17. The equations for at least one of these classes (*breeding mature ewes*) have been confirmed as wrong and will be corrected in the 2018 version of the inventory. Further details on this particular correction are attached in the document *Error in calculation of sheep populations for class Mature breeding ewes*, which show that the revised emissions estimates for 2015 would be 33 kt CO2-e lower (equivalent to 0.09% of agricultural emissions).

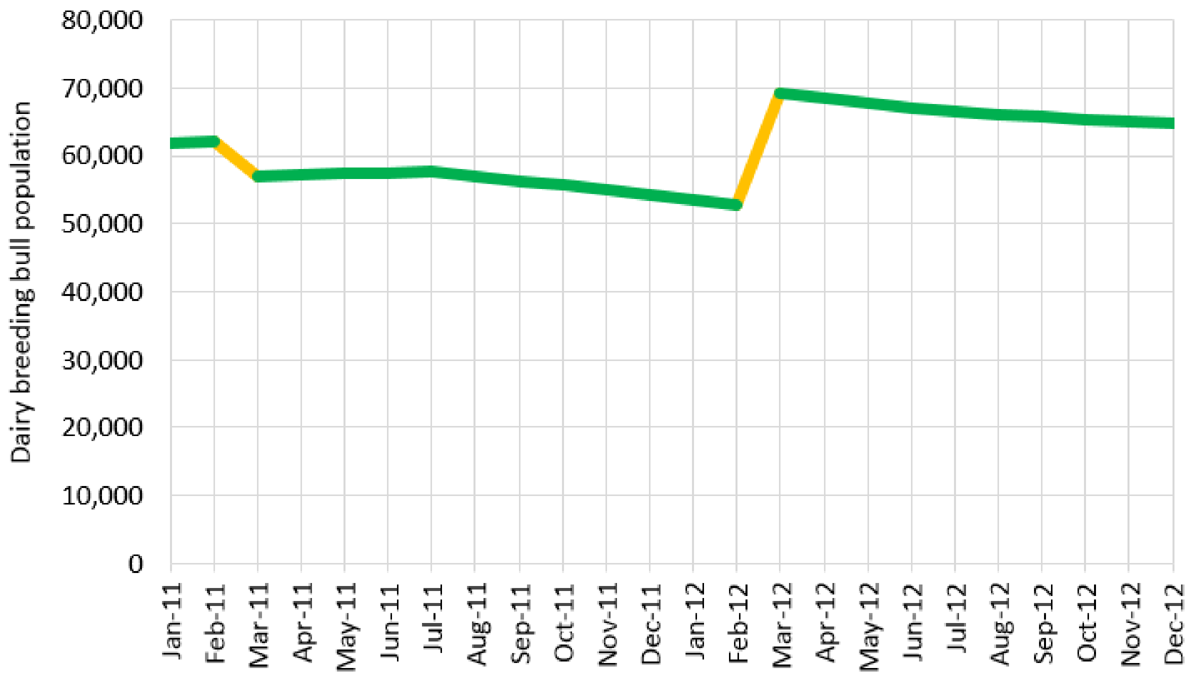
18. Corrections for the other classes listed here are not as straightforward (as the correction for *breeding mature ewes*) as it not clear how these inconsistencies could be resolved and what the ideal population variation within a year should look like. An example of the issues being encountered is shown for the *dairy breeding bulls* population where the change in population between February and March is sometimes declining and sometimes increasing, which raises the following questions:

    a. Are the outputs of the current model correctly representing the population changes that normally occur between February and March?
    b. Are the death rate assumptions used in the model still valid?
    c. Are there errors in how the code in the population model is applied for this class?

[6] Clark H, Brookes I, Walcroft A. 2003. *Enteric Methane Emissions from New Zealand Ruminants 1990–2001 Calculated Using an IPCC Tier 2 Approach*. Report prepared for the Ministry of Agriculture and Forestry by AgResearch and Massey University. Wellington: Ministry of Agriculture and Forestry

[7] Clark H. 2008. *Guidelines to Accompany Computerised Inventory*. Report prepared for the Ministry of Agriculture and Forestry by AgResearch. Wellington: Ministry of Agriculture and Forestry.

Figure 1: Estimated monthly population of breeding bulls in 2011 and 2012



19. The inventory team is looking at commissioning a research project that will review the population model in the inventory and provide recommendations as to how it could be improved. It is hoped that these recommendations will be presented to the Agricultural Inventory Advisory Panel for consideration in 2018.

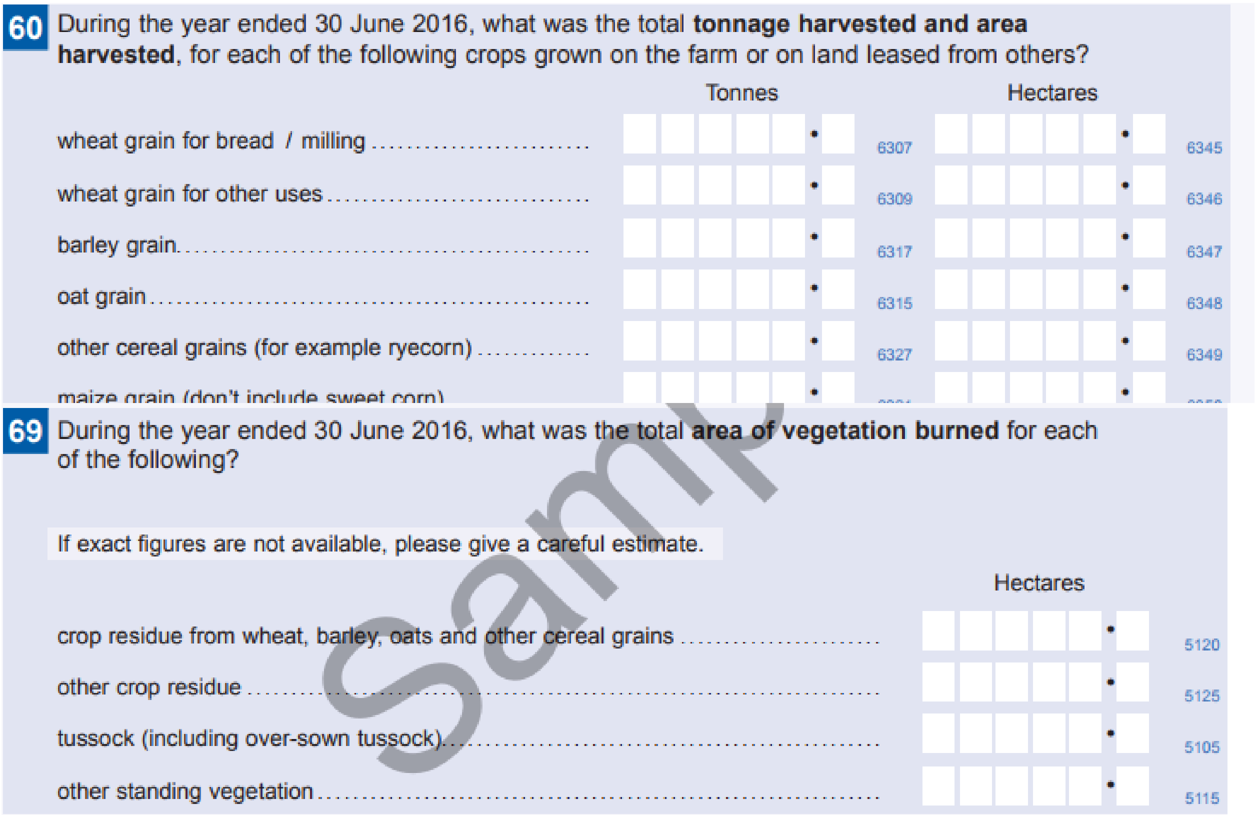
Calculating the areas of crop residues burned

20. The burning of crop residues following harvest results in emissions of CH_4, CO, N_2O and NO_x. These emissions are estimated using country-specific parameters, emission factors and methodology which is aligned with the 1996 Intergovernmental Panel on Climate Change (IPCC) methodology (Thomas et al., 2011)[8]. In New Zealand it is assumed that only the residues from barley, oat and wheat crops are burnt. These emissions are recorded in the *Field burning of agricultural residues* category of the inventory, which caused 22 kt of CO2-e in 2015. This is equivalent to around 0.06% of agricultural emissions.

21. A critical part of estimating emissions from field burning is the estimation of the areas of crops that are burned after harvest. The current methodology used to calculate area burning (used from 2005 onwards) is shown in figure 3, and is documented in Thomas (et al., 2011).

22. This methodology is required because while the Agricultural Production Survey (APS) collects data on the total area of individual crops (barley, oats and wheat) grown, it only collects data on the aggregate area of these crops burned (i.e. it does not break the burned areas down into the individual crop types). When using this methodology, the proportion of wheat area burned is fixed at 70% (of the total wheat crop), even in years where there is less crop burning than normal.

Figure 2: Extract from Agricultural Production Survey questionnaire – crop areas harvested and burnt



60 During the year ended 30 June 2016, what was the total **tonnage harvested and area harvested**, for each of the following crops grown on the farm or on land leased from others?

	Tonnes		Hectares	
wheat grain for bread / milling	.	6307	.	6345
wheat grain for other uses	.	6309	.	6346
barley grain	.	6317	.	6347
oat grain	.	6315	.	6348
other cereal grains (for example ryecorn)	.	6327	.	6349
maize grain (don't include sweet corn)	.		.	

69 During the year ended 30 June 2016, what was the total **area of vegetation burned** for each of the following?

If exact figures are not available, please give a careful estimate.

	Hectares	
crop residue from wheat, barley, oats and other cereal grains	.	5120
other crop residue	.	5125
tussock (including over-sown tussock)	.	5105
other standing vegetation	.	5115

[8] Thomas S, Hume E, Fraser T Curtin D. 2011. *Factors and Activity Data to Estimate Nitrous Oxide Emissions from Cropping Systems, and Stubble and Tussock Burning*. Report prepared for the Ministry of Agriculture and Forestry by Plant and Food Research http://www.mpi.govt.nz/dmsdocument/2957

Figure 3: Schematic diagram of how crop burning areas are calculated

23. In 2015 and 2016 a dramatic fall in the recorded area of crop burning uncovered shortcomings with the current crop area burning methodology.

24. The area of wheat residues burned is calculated *before* the areas of barley and oat burning areas are calculated, which can lead to the situation where the estimated areas of barley and oat crops burned are significantly reduced compared to previous years. This is shown in table 2 where the estimated proportion of barley and oat area burned falls dramatically between 2014 and 2015.

Table 2: Estimated areas of barley, oat and wheat crops burned, 2013 to 2016 – Current inventory values in normal black, proposed values (from paragraph 26b) in *red italic text*

		2013	2014	2015	2016
Barley crop area (APS) (hectares)		61,328	59,337	64,164	51,892
Oats crop area (APS) (hectares)		5,444	6,662	5,803	8,428
Wheat crop area (APS) (hectares)		49,179	47,932	47,685	49,945
Total crop burning area (APS) (hectares)		58,432	50,172	34,503	39,784
Estimated crop burning area (hectares)	barley and oats	24,007	16,620	1,124	4,823
	barley	22,049 *26,423*	14,942 *22,366*	1,030 *16,192*	4,149 *15,851*
	oats	1,957 *2,346*	1,678 *2,511*	93 *1,464*	674 *2,574*
	wheat	34,425 *29,664*	33,552 *25,294*	33,380 *16,847*	34,962 *21,359*
Estimated proportion of barley and oat area burned		0.36 *0.43*	0.25 *0.38*	0.02 *0.25*	0.08 *0.31*
Estimated proportion of wheat area burned		0.70 *0.60*	0.70 *0.53*	0.70 *0.35*	0.70 *0.43*

25. It is important to note that the inventory team is not concerned with estimates of the *total* crop area burned, as this value is estimated using robust data from the APS. The main issue lies around how the total crop burning area is *apportioned* between barley, oats and wheat.

26. The inventory team is discussing this issue with Plant & Food Research, who will provide additional advice on how to obtain more accurate estimates of crop burning by individual crop. A couple of possible options are below:

    a. Using unit-record data from the APS to get a more accurate picture of crop burning for the different crop types. This may improve the burned area estimates, but would be more time-consuming to analyse.

    b. Assuming the proportions of burned area are equal to the proportions used before 2005 (50% for barley and oats, 70% for wheat) then adjusting these figures up or down so the sum of burned areas match the figures used in the APS. An example of these values are shown in table 2, in *italic red text*.

27. Field burning area estimates also have an impact on emissions from the *Agricultural Soils* category, as any crop residues that are not burned generate N_2O through their decay. Holding all else equal, an increase in crop burning area (and crop burning emissions) will result in lower *Agricultural Soils* emissions.

28. Any change to the estimation of crop burning areas would have a minimal effect on emissions. Depending on the solution that is implemented, estimated emissions for 2015 would increase or decrease by around 2 kt CO2-e, or 0.005% of total agricultural emissions.

29. Although emissions from the *Field burning of agricultural residues* category make up an insignificant proportion of New Zealand's agriculture inventory, emissions from barley, oat and wheat residue burning are reported separately in the common reporting format (CRF) tables submitted to the UNFCCC. Any significant deviations in emissions trends for these crops could be questioned in future reviews, and we should ensure that our emissions estimates for these categories are as accurate as possible.

Strategic opportunities

30. Under the UNFCCC, countries should consider ways to improve the transparency and accuracy of their inventory. By continuing to comprehensively document the AIM, more errors are likely to be found and corrected, which will lead to:

    a. New Zealand continuing to meet its UNFCCC obligations.

    b. An improved understanding of emissions drivers and trends for better policy.

Next steps

31. The corrections discussed here will be implemented in next year's version of the inventory, and future work reviewing the population model will be considered.

Recommendations

It is recommended that the Agricultural Inventory Advisory Panel:

32. *Note* the correction that was made in the 2017 (1990-2015) NIR version of the AIM, regarding the amount of nitrogen retained by sheep in the production of wool.

33. *Note* the corrections that are planned for the 2018 inventory submission:

    a. Corrections to parts of the population model.

    b. Improving the methodology used to estimate the areas of barley, oat and wheat crops burned.

34. *Note* the actions being taken to find other errors in the model and to improve its transparency.

Agree / not agreed

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Approved/ Not Approved/ Approved as Amended

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Date