Review of Draft Report

Accounting for the effect of slope on direct N_2O emissions from hill country soils

by Donna Giltrap, Landcare Research; Surinder Saggar, Landcare Research; Rob Davison, Beef + Lamb New Zealand; Rob Gibson, Beef + Lamb New Zealand

R W Tillman

June 2014

General Comments

1. This document is a review of a draft report that makes use of methodology developed by Saggar and Giltrap (2012 *unpublished*) to calculate annual N_2O emissions from the excreta of sheep, beef and deer each year from 1990 until 2012. The methodology uses the latest experimentally-determined EF_3 values for excreta deposited on land of different slopes by sheep and cattle.
   Response: Correct
2. The resulting estimates of the N_2O emissions from the excreta of sheep, beef and deer are approximately 50% lower than the estimates made currently in the New Zealand Agricultural Greenhouse Gas Inventory model. This is an important finding.
   Response: Correct
3. In the introduction to the report it could be stated more clearly that the estimates in the current inventory model use EF_3 values of 0.01 and 0.0025 for urine and dung respectively, irrespective of the type of animal and the slope of the land on which the excreta was deposited. This is stated clearly on P11 in the final paragraph of Section 3.3, but it would be helpful to have it stated more clearly at the outset.
   Response: Agreed, the statement is added
4. The report calculates that annual N_2O emissions from the excreta of sheep, beef and deer have decreased by approximately 18% from 1990 to 2012. This decrease is largely due to a decrease in the number of animals.
   Response: Correct

5. In developing their new methodology the authors obtained data from a number of different sources. Some of these data had to be adjusted to fit the calendar year time-step in the methodology. Also, in some instances where published data was not available (e.g. the relative spatial distributions of dung and urine), the authors had to make assumptions based on field observations and a general knowledge of nutrient cycling in hill country. All these adjustments and assumptions appear reasonable but they do introduce uncertainties into the estimates of N_2O emissions.

   The authors acknowledge these uncertainties but state that as yet they have not completed sensitivity analyses to quantify the likely significance of most of these sources of uncertainty. I think it is important that these sensitivity analyses are completed (although not necessarily for this report). It is unlikely that these uncertainties will seriously affect the overall conclusions of the study, but it is important that they are documented for completeness and acceptance of the methodology by international commentators.
   Response: Agreed, the uncertainties about the EFs have been studied in Kelliher et al. (2014).
6. The authors may wish to consider whether the title of the report accurately reflects its content. The title of the report is "Accounting for the effect of slope on direct N_2O emissions from hill country soils". However, the report seems to focus on the emissions from all sheep, beef and deer in New Zealand – regardless of whether they are farmed on hill country or flat land. For example, on P4 one of the "Farm Class and Region" combinations listed is "Marlborough/Canterbury Mixed Finishing (MC Mix)". Data in Table A2 suggests that in most years this "Farm Class and Combination" is comprised mainly of low slope land, with little or no high slope land. This is to be expected and many of the mixed cropping farms included in this category would be almost entirely flat. Should these farms be included in a report that, according to the title, is focused on hill country soils?
   Response: Title of the report amended to reflect the contents and the scope of this report.
7. A related point is that the report does not consider emissions from dairy and particularly "dairy support" farming operations that may be taking place on hill country. The report identifies on P5 that between 1990-91 and 2012-2013 there has been a reduction of 0.9 million hectares of low slope land and 0.3 million hectares of medium slope land that is grazed by sheep, beef and deer. Much of this reduction is attributed to the expansion in dairying. Should a report titled "Accounting for the effect of slope on direct N_2O emissions from hill country soils" include consideration of those dairy operations that take place on sloping land? The factors causing a

decrease in EF_3 with increasing land slope are likely to apply equally to excreta from dairy cattle as beef animals.

Response: Correct, but in the absence of dairy cattle EF3 data on medium and high slopes a conservative approach is applied by applying the same EF3 values for dairy cattle urine and dung for both the low and medium slope land grazed by dairy cattle in the national inventory estimates.

8. In a final point relating to the title it is apparent that the allocation of dung and urine to sheep and cattle separately (with their differing EF_3 values) is making almost as big a contribution to the decrease in estimated N_2O emissions (compared to the current inventory) as allocating different EF_3 values to different slopes. Should this be reflected in the title, and also in the conclusions?

   Response: The title of the report has been amended and the suggestions included in the conclusions.

More detailed comments

9. I have attached a copy of the report with some comments inserted and some minor suggested editorial changes. These are tracked for easy acceptance or rejection.

   Response: The editorial suggestions and minor comments have been accepted and addressed accordingly.

10. It may be helpful on P5 to include more detail on how the slope data in each region is calculated and provided by Beef + Lamb.

    Response: The slope data in each region were calculated and provided by Beef + Lamb.

11. In Tables 3 and 4 and Equations 1-6 I had difficulty with the formulae for calculating the allocation of dung and urine to low and high slope land when the proportion of that land is very low (<0.01). I have put a more detailed comment on the text. The authors may wish to check the formulae. But I may be mistaken and have simply misunderstood the calculation.

    Response: The typographical errors in Tables 3 and 4 and Equations 1-6 were introduced when converting from % to fraction units. These do not affect the results. Thanks for spotting these. We have corrected the tables accordingly.

12. Further to the point raised in Paragraph 11, the allocation of animal excreta to different slopes is based on data from a single trial at Whatawhata. This trial involved 5 paddocks. The authors of the report note that within these 5 paddocks the distribution of dung across the different slopes was reasonably constant, despite the proportions of the total area occupied by the different slopes varying between the paddocks. Based on this observation the authors have used this excretal distribution as the basis of their model. This is a reasonable approach.

However, the authors have recognized that the Whatawhata data can only be used to predict the distribution of excreta on hill country slopes when the distribution of slopes in the landscape falls within the range of slope distributions at Whatawhata. When the slope distributions fall outside those in the Whatawhata data a different approach has to be used. This is usually when the slope category in question occupies either a very small or a very large proportion of the landscape

Logically, as the area of a given slope tends towards zero the proportion of excreta allocated to that slope should also tend towards zero. Similarly, if a slope category occupies 100% of the land area then 100% of the excreta should be allocated to it. The authors of this report have recognized this and Tables 3 and 4 (together with Equations 1-6) describe a process for calculating the distribution of animal excreta on various slope categories in situations where the proportion of the total area occupied by those slope categories falls outside the range of slope distributions in the Whatawhata data.

I am happy with the general concept but the detail of the process used appears to be a little "clumsy". For example, when the area of low slope is between 9 and 35% of the total area it is assumed that 61% of the dung is excreted on that slope category. This figure comes from the Whatawhata data – (although in the text I have inserted a query as to why the lower bound of 9% was used).

When the area of low slope increases above 35% of the total area, a sequence of simple linear equations is used to gradually increase the estimated proportion of dung falling on the low slope areas. Eventually, when the low slope areas occupy 100% of the total area, 100% of the dung is allocated to that area. Although this approach is not based on experimental data (because none is available), the approach appears to be sensible and logical.

In contrast however, when the area of low slope is less than 9% of the total area a slightly different approach is used. Rather than a gradual linear decrease in the proportion of dung deposited on low slopes as their area decreases, there are a series of step changes. Thus, when low slopes occupy between 5 and 9% of the total area, the proportion of dung deposited on those low slope areas is assumed to be 45% (compared to 61% when low slopes occupy more than 9% of the total area). When the low slopes occupy between 1 and 5% of the total area the proportion of dung deposited on those slopes drops to 30%. It is only when the area of low slopes

is less than 1% of the total area that a simple linear equation is again used (subject to the question in Paragraph 11) to calculate the proportion of dung deposited on that area.

It is not explained in the report why it was decided to use the "step-change" approach rather than a linear model. The authors of this report, (and the earlier report in which the methodology was originally developed (Saggar and Giltrap, 2012 *unpublished*)), are very experienced researchers and so I am sure there will an excellent reason. But it is apparent that the use of such step-changes does cause some anomalies in the calculation of N_2O emissions. The authors have discussed this some detail in Section 5.2 and it is apparent that the overall impact on the calculation of N_2O emissions is small. But it would be helpful if the authors could include an explanation of why they have used the approach they have.

Response: We acknowledge that there are many approaches that could be used to allocate excretal N for slope distributions outside of the measured ranges. The Whatawhata experiments showed that the animals had a strong preference to spend more time on lower slopes, and that there was little dependence between the proportion of low slope area and the proportion of time spent on low slope. We thought the step function better reflected these trends even though it does lead to potential variances around the break points. However, no sudden changes in the total N_2O emissions time series were observed as there are 17 regional farm classes and so a step change in the N allocation in one regional farm type is still small relative to the total N_2O emissions.

13. It would be very useful to include an additional figure that has a similar format to Figures 5 and 6 and which shows the percentage of total N_2O emissions from each of the three slopes from 1990 to 2012. This would provide valuable information on where further research should be targeted. For example, if such a figure shows that the high slope areas contribute only a small fraction of the total N_2O emissions from excreta deposited on hill country, then there is little point in spending large amounts of time and money attempting to refine this estimate still further.
Response: An additional figure has been included in the report showing the percentage contribution of each slope category to total N2O emissions from 1990 to 2012. This Figure 7 shows N2O emissions between the slope classes remains fairly steady over times with the majority of emissions from the low slopes due to the higher EFs.

14. Throughout the report there are several statements along the lines of *"The proposed methodology reduced the total N_2O emissions between……"* (P17). A minor and perhaps pedantic point is that the methodology has no impact on the actual total N_2O emissions at all. The methodology is producing an estimate of the total N_2O emissions. Perhaps the wording should be *"The proposed methodology reduced the estimate of total N_2O emissions between……"* and similarly throughout the document.

Response: Agreed and the word "estimates" has been added as suggested.

References

Saggar S, Giltrap D (2012) Nitrogen and nitrous oxide (N2O) emissions from livestock excreta on New Zealand hill country. Landcare Research Contract Report LC1189 for MPI.

Response: Reference added