# Framework for up-scaling nitrous oxide emissions from New Zealand hill country

**Cecile de Klein**[*A]
**Coby Hoogendoorn**[B]
**Surinder Saggar**[C]
**Andrew Manderson**[B]
**Donna Giltrap**[C]
**Craig Briggs**[D]
**Jacqueline Rowarth**[E]

[A] AgResearch Invermay, Private Bag 50034, Mosgiel, New Zealand; [B]AgResearch Grasslands, Private Bag 11008, Palmerston North 4442, New Zealand; [C] Landcare Research, Private Bag 11052, Manawatu Mail Centre, Palmerston North 4442, New Zealand; [D] Landcare Research, Private Bag 3127, Hamilton 3240, New Zealand; [E] Institute of Natural Resources, Massey University, Private Bag 11222, Palmerston North 4442, New Zealand *Cecile.deklein@agresearch.co.nz

## Objectives

- **Develop a framework for up-scaling $N_2O$ emissions from New Zealand hill country**
- **Identify hill land units that contribute most to the total $N_2O$ emissions**

## Background

- Urine from grazed animals is the largest source of $N_2O$ in New Zealand
- Hill land comprises 60% of total farmed area in NZ
- Large **topography-driven** spatial variability, both in N excreta rates and $N_2O$ emissions

## Approach

$$N_2O \text{ Hill country} = \Sigma_i (HLU_i \bullet Nreturn_i \bullet EF_{3i})$$

$HLU_i$ = Area of land in Hill Land Unit $i$, as defined by slope, aspect, and drainage class; $i$ = 1, …18 (ha)
$Nreturn_i$ = amount of excreta N deposited in HLU $i$ (kg N excreted/ha)
$EF_{3i}$ = $N_2O$ emission factor for N deposited in HLU $i$ (kg $N_2O$-N/kg N excreted)

***1. Defining HLU (Figure 1)***

- Hill country definition from NZLRI[1] intersected by i) sheep/beef farms, ii) land with pasture cover, and iii) land below the tree-line.
- 18 hill land units defined based on 3 soil drainage classes x 3 slopes x 2 aspects.

***2. Estimating Nreturn***

- Total number of stock from the 2007 Agricultural Production Survey (Statistics New Zealand) and Agribase™.
- N excretion rates from total stock numbers and N excreted per animal as in NZ inventory method [2].
- A nutrient transfer model (NTM)[3] to calculate the proportional distribution of excretal N for each HLU.

***3. Assigning $EF_{3i}$ values***

- Each HLU was assigned a potential $EF_3$ category: very high, high, moderate, low and very low.
- Six scenarios run to assess relative impact of emission factor values (Table 1) and to identify key HLUs.

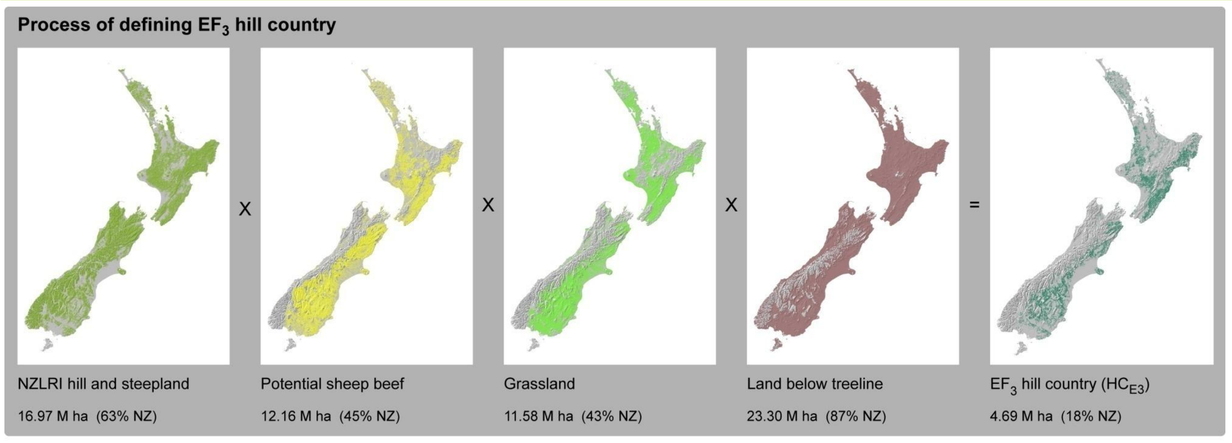
**Table 1: Assigned emission factor scenarios ($EF_3$; %)**

| $EF_3$ category | HLUs* | I# | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| **Very high** | PNL, PSL | 1.00 | 2.00 | 1.50 | 1.00 | 0.50 | 2.50 |
| **High** | MNL, PNM | 1.00 | 1.50 | 1.00 | 0.75 | 0.25 | 1.00 |
| **Moderate** | FNL, MNM, MSL, PSM | 1.00 | 1.00 | 0.60 | 0.50 | 0.10 | 0.20 |
| **Low** | FNM, FSL, MSM, PNH, PSH | 1.00 | 0.50 | 0.30 | 0.25 | 0.05 | 0.05 |
| **Very Low** | FNH, FSM, FSH, MNH, MSH | 1.00 | 0.05 | 0.05 | 0.05 | 0.01 | 0.001 |

*HLU code: **XYZ** = drainage, aspect, slope; Drainage = F, M, P (free, moderately well drained, poorly); Aspect = N, S (NW and SE); Slope = L, M, H (low <12º, medium 12-25º, high >25º)

#Scenario I = $EF_3$ set at 1 % for all HLUs
Scenario II = $EF_3$ relatively high for all HLUs
Scenario III = $EF_3$ moderately high for all HLUs
Scenario IV = $EF_3$ moderate for all HLUs
Scenario V = $EF_3$ low for all HLUs
Scenario VI = $EF_3$ ranges very high to very low

## Results



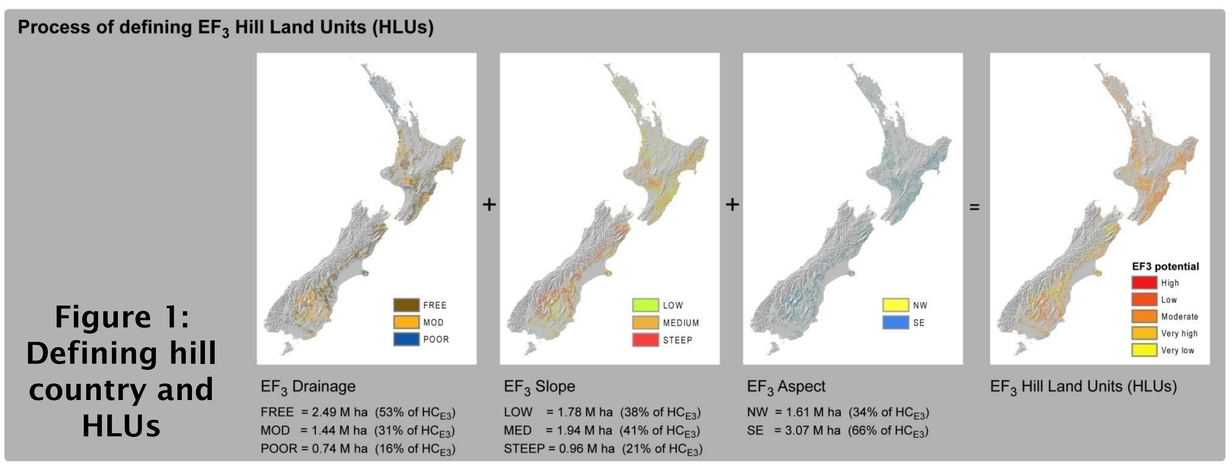




**Figure 1: Defining hill country and HLUs**

**Table 2: Relative contributions of land area, N return and $N_2O$ emissions per drainage class, aspect and slope category**

| | | Area | N return | $N_2O$ emissions scenarios (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (%) | (%) | I | II | III | IV | V | VI | Range |
| **Drainage** | Free | 53 | 53 | 53 | 26 | 32 | 32 | 22 | 5 | 5–53 |
| | Moderate | 31 | 31 | 31 | 36 | 31 | 35 | 30 | 20 | 20–36 |
| | Poor | 16 | 16 | 16 | 38 | 37 | 33 | 48 | 75 | 16–75 |
| **Aspect** | NW | 34 | 34 | 34 | 47 | 41 | 45 | 46 | 50 | 34–50 |
| | SE | 66 | 66 | 66 | 53 | 59 | 55 | 54 | 50 | 50–66 |
| **Slope** | Low | 38 | 57 | 57 | 84 | 78 | 77 | 82 | 91 | 57–91 |
| | Medium | 41 | 31 | 31 | 14 | 19 | 21 | 16 | 8 | 8–31 |
| | High | 21 | 12 | 12 | 2 | 3 | 3 | 2 | 1 | 1–12 |

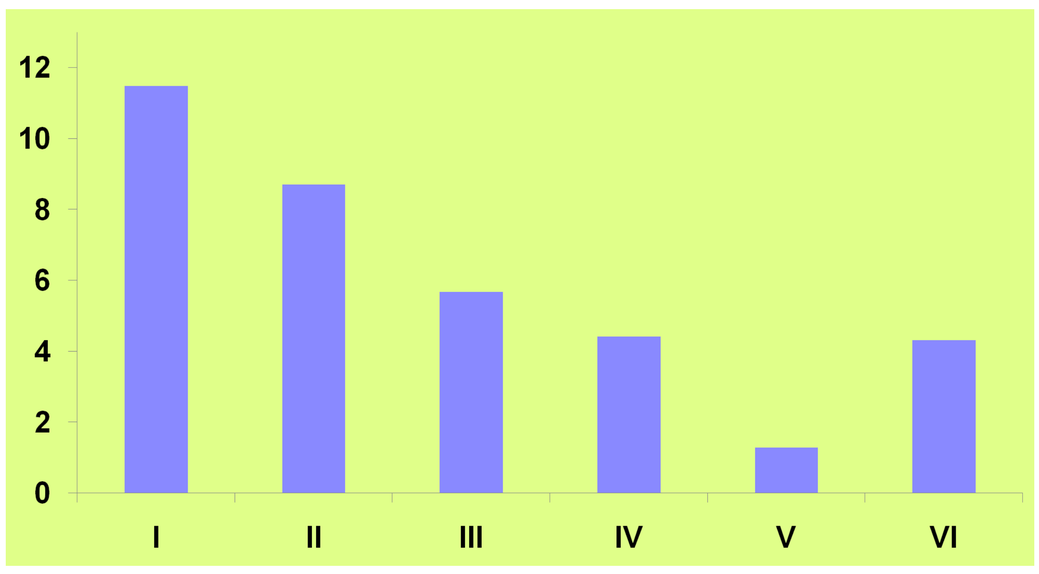



**Figure 2: Estimated total $N_2O$ emission (Gg $N_2O$) from New Zealand hill country for the six scenarios**

## Conclusions

- **The proposed framework can successfully account for topography-driven spatial variability**
- **For all scenarios, total $N_2O$ emissions were lower than current estimate**
- **Low slopes receive majority of N and can contribute up to 90% of the total emissions**
- **Poorly draining soils receive only 16% of N but can emit up to 75% of total emissions**
- **Low and medium slopes on free draining soils receive almost 50% of N and refinement of $EF_3$ for these HLUs is critical**

agresearch
Farming, Food and Health. First
*Te Ahuwhenua, Te Kai me te Whai Ora. Tuatahi*

Massey University
Manaaki Whenua Landcare Research

**Acknowledgement**
This study was funded by the New Zealand Ministry of Agriculture & Forestry

**References**

[1] NZLRI: New Zealand Land Resource Inventory
[2]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 (March 2003).*
[3] Saggar S, Rowarth J, Hoogendoorn C, de Klein C (2009) Application of a nutrient transfer model for upscaling nitrous oxide emissions from grazed hill country pastures. Poster at MC2 conference, Palmerston North, New Zealand, 18-20 Nov 2009.