Landcare Research
Manaaki Whenua

Three alternative approaches to regional/national upscaling DNDC: a New Zealand case study

Donna Giltrap, Anne-Gaelle Ausseil, Surinder Saggar

Introduction

- The agricultural sector is the largest source of greenhouse gas emissions in New Zealand (47% of total).
- N_2O emissions (mostly from agriculture) account for 14.7% of total inventory
- >50% of New Zealand’s land area is in grassland
- N_2O emissions from grazed pastures are an important, but highly variable, greenhouse gas source

New Zealand specific emission factors:

- 1% - fertiliser N; animal urine direct deposit onto pasture
- 0.25% - animal dung direct deposit onto pasture

NZ-DNDC

- Based on DNDC version 8.6K
- Includes perennial pasture crop type
- Modifications to hydrological sub-model (Priestley-Taylor PET)
- Soil surface temperature/air temperature relationship modified.
- Typical NZ values for animal dry matter intake and N excretion

Scaling Up: Sources of error

- Model error
- Availablility, accuracy and scale of input data
- Variability within a unit* (Most Significant Factor)

Scaling Up: Assumptions

- Consider direct N_2O emissions only
- Anthropogenic emissions – subtract "background" emissions
- All animal manure directly applied to pasture
- Dairy rotationally grazed; Sheep, beef, (deer) set stocked
- Total manure and fertiliser N application scaled to match regional totals

Case study: Manawatu-Wanganui Region

Manawatu-Wanganui Regional Statistics (Year ended June 2003)

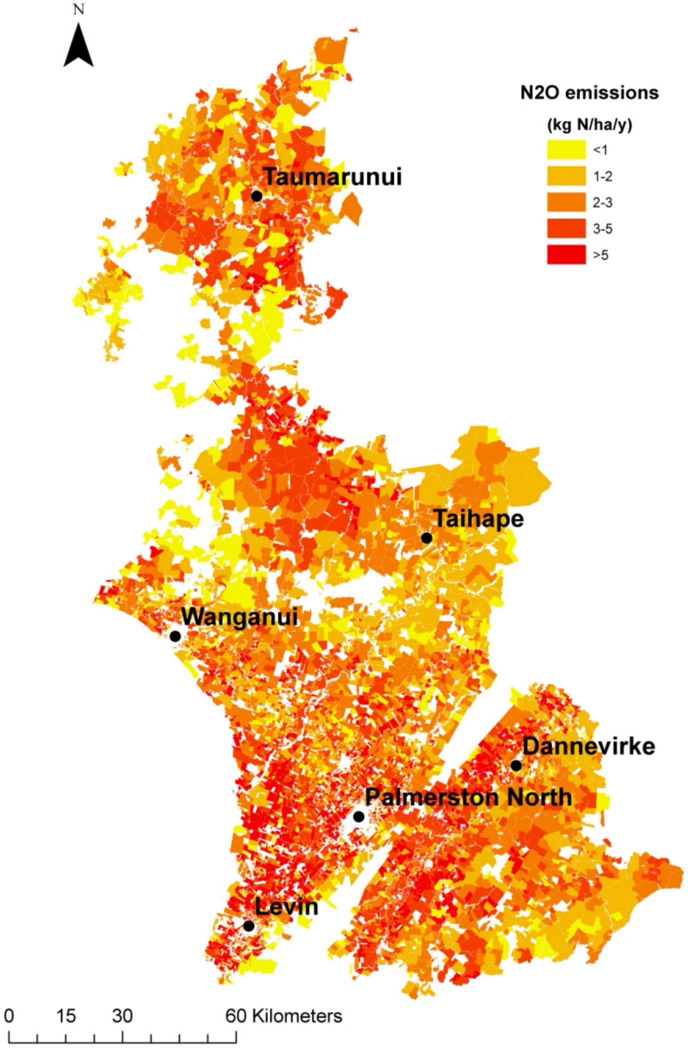
Total land area (Approx. 60% pastoral)	2,221,100 ha
Sheep	6,633,203
Beef Cattle	713,348
Dairy Cattle	408,986
Deer	136,232
Total fertiliser (tonnes N)	22,997

3 Methods

Method 1

- Area divided into sub-units
- Animal distribution estimated from farm survey's (not very accurate)
- Soil properties from national soils database
- Average stocking rate used throughout region (extra feed assumed when needed)
- Climate data from nearest climate station (2002/03 data only)
- No irrigation
- Calculate N_2O emissions and background emissions for each sub-unit

Method 1



- Net anthropogenic N_2O emission = 4.4 $\pm$ 1.5 Gg N_2O-N
- Using NZ specific emisison factors = 1.6 Gg N_2O-N

(uncertainty -42% to +74%)

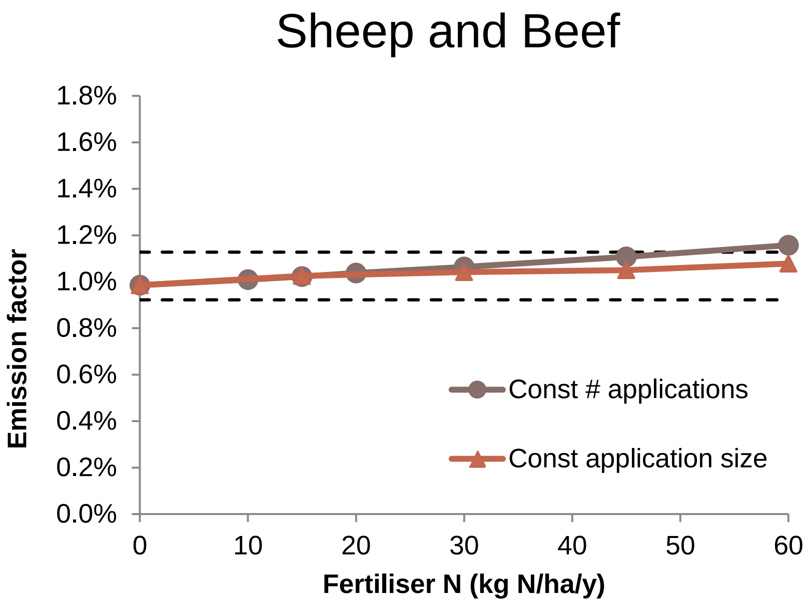
- Average stocking rate meant some pastures under/over-utilised

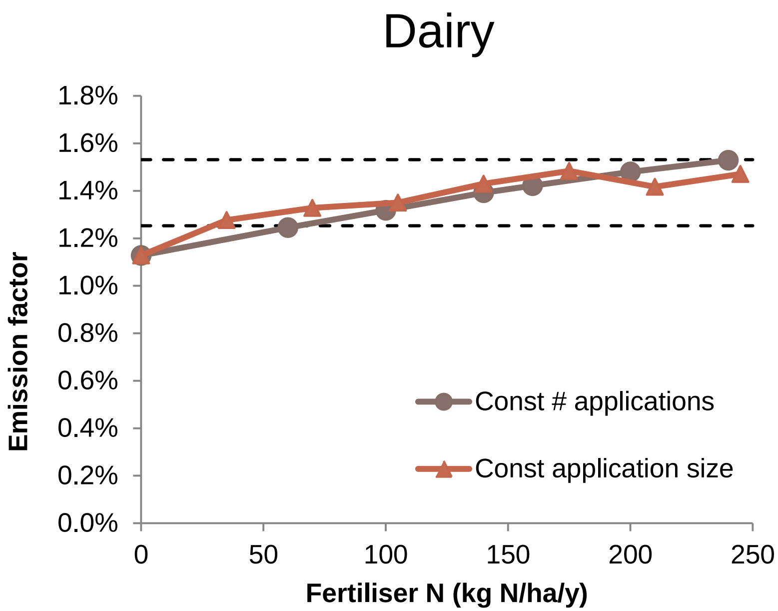
Ref: Giltrap D, Saggar S, Li C, Wilde H (2008). Plant and Soil 309(1):191-209

Method 2

- Look-up tables of long-term average EF based on climate zone (LENZ lvl 2), soil type (NZSC sub-group) and farm type
- Multiple simulations (>1M) run for all combinations of soil properties, farm type, using 20 years of climate data
- Stocking rates set to maximise pasture utilisation (no additional feed imported)

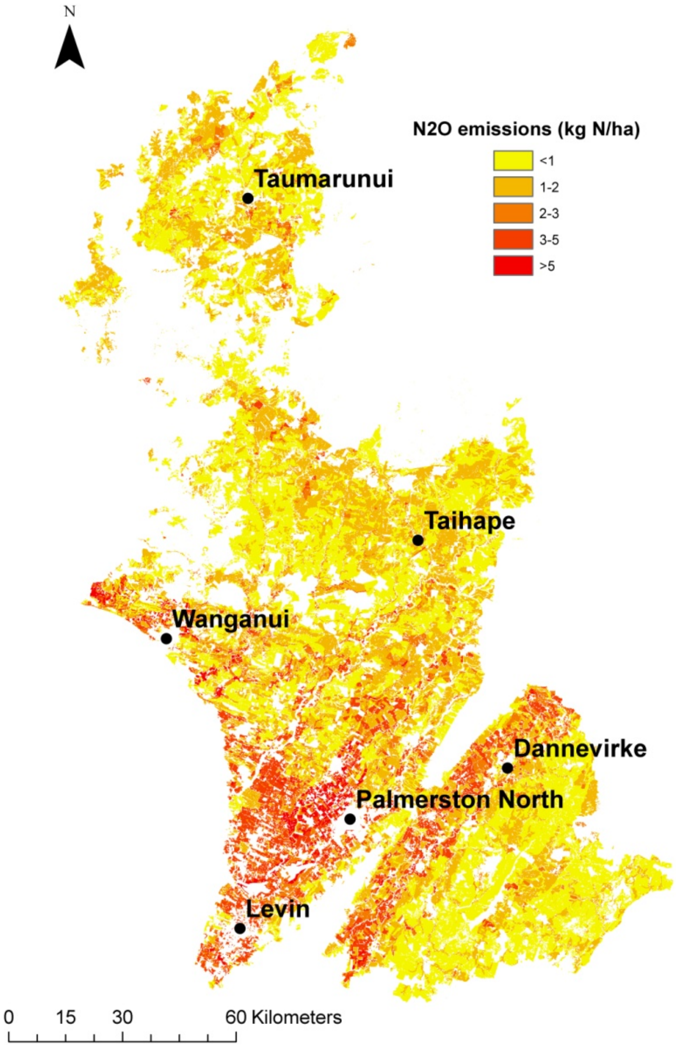
EF is not highly sensitive to N application rate





Ref: Giltrap D, Ausseil A-G, Thakur K, Sutherland A. Science of the Total Environment (in press)

Method 2



- Net anthropogenic N_2O emissions = 1.6±1.6 Gg N_2O-N
- Differences potentially due to N input distribution, multi-year average climate
- High uncertainty due to uncertainty of soil properties within a "class"

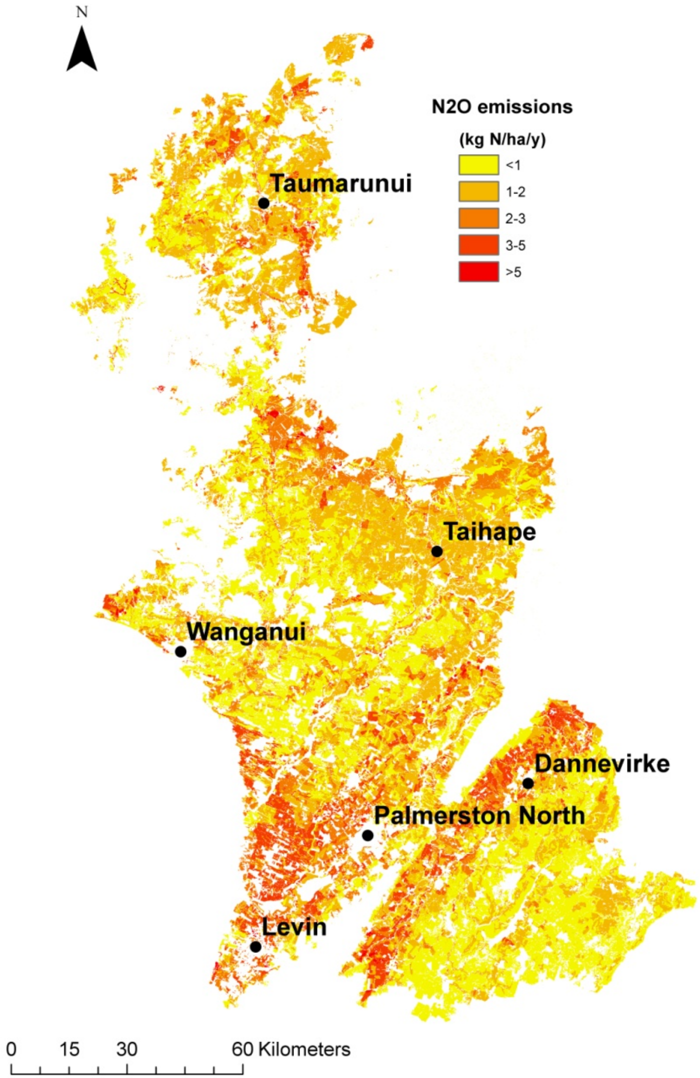
Method 3

- Fit a regression model to the simulation data generated for Method 2

EF ~ FarmType*(SOC + TextureClass)

- Use modelled SOC surface instead of NZSC sub-groups (error?)
- Regression introduces additional error (R^2=0.61)
- Can select regression model based on data availability, goodness of fit, parameters of interest

Method 3



- Net anthropogenic N_2O emissions = 1.6 ± 0.7 Gg N_2O-N
- Agrees with Method 2 but uncertainty reduced
- Uncertainty in modelled SOC layer?

Ref: Giltrap and Ausseil (2013). Extended abstract, MODSIM 2013

Summary

- Adjusting stocking rates to match land productivity (Method 2) produced much lower N_2O emission estimates than assuming a fixed stocking rate (Method 1)

→ Information about stock movement, feed imports and silage making could be important

- Method 2 had high uncertainties due to large ranges of soil properties within the soil categories

- Method 3 reduced the uncertainty in Method 2 by using an interpolated SOC layer and regression relationship.

Not assessed

- NZ-DNDC model error
- Error in underlying datasets
- Full range of possible management options (e.g. imported feed, stock movement between farms, silage/hay making)

Conclusions

- Spatial variability of animal stocking rates is important.
- The choice of upscaling method depends upon data availability/quality
- Regression “meta-modelling” can be used to find models that suit the available data.