Reducing N_2O emissions from grazed pasture systems and options for including these in national inventories

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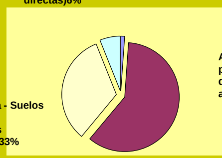
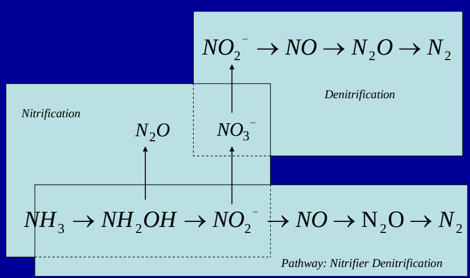
N_2O emissions: 9.7 $MtCO_2$-e



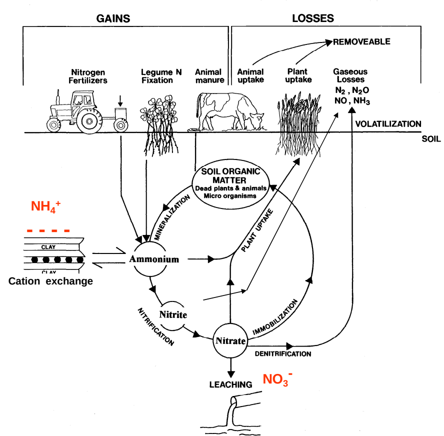
- 99% of N_2O emissions in 2002 originated in agriculture,
- 90% of them from grazing animals (dung and urine deposited by free-range grazing animals).

(Luis Santos 2007)

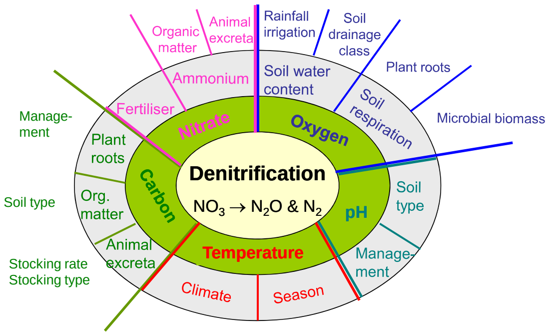
N_2O formation pathways



Wrage et al. 2001 Soil Biology & Biochemistry

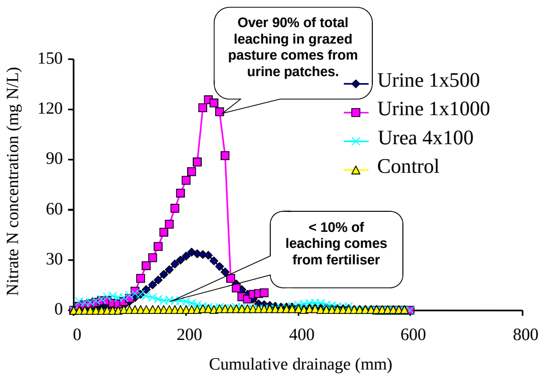


Factors affecting denitrification rates in soils

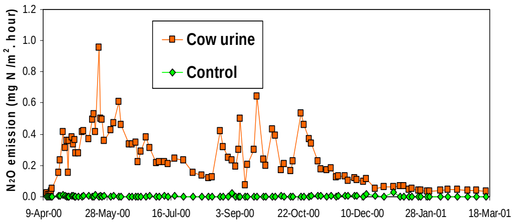


In grazed pastures urine patches are the main sources of nitrous oxide emissions and nitrate leaching

Nitrate leaching is greatest below the animal urine patch



N_2O emissions from urine amended soil



Source: Sherlock et al. (unpubl. data)

How can we mitigate N_2O emissions from excreta N?

- Change the animals diet?
  - modify the C/N ratio?
- Stand-off/feed pads?

Covered feed & loafing pad

(Cecile De Klein, AgResearch 2008)

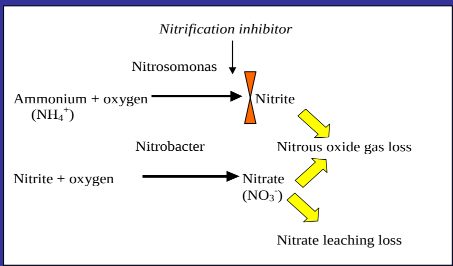
Uncovered feed & loafing pad

(Cecile De Klein, AgResearch 2008)

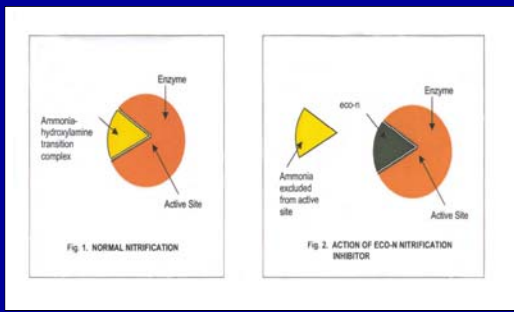
How can we mitigate excreta N?

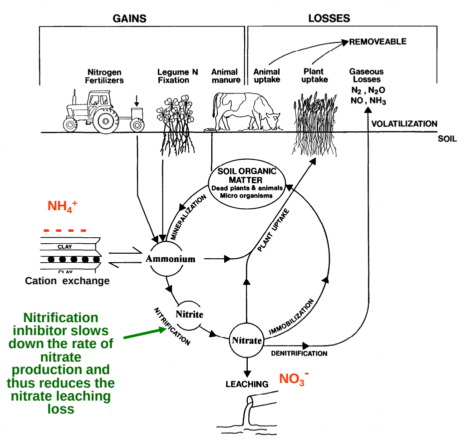
- Change the animals diet?
  - Increase C and modify the C/N ratio?
  - Stand-off/feed pads
  - Use nitrification inhibitors e.g. dicyandiamide (DCD)

DCD reduces the activity of the *Nitrosomonas* bacteria in the soil (Bacteriostatic effect)

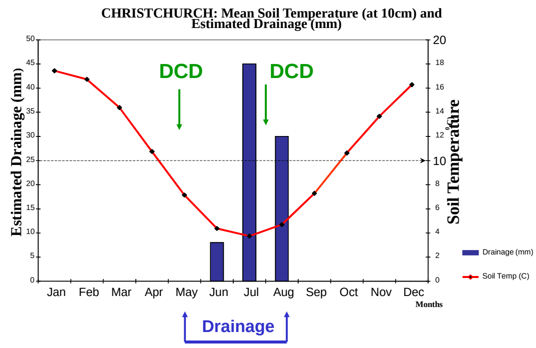


The inhibitor temporarily blocks the active site of a specific enzyme (ammonia monooxygenase)

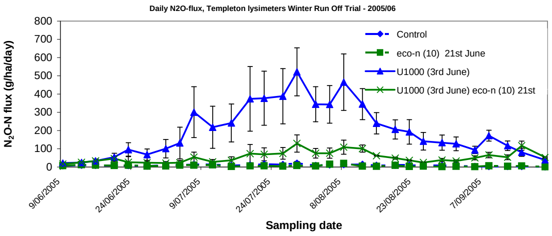




Recommend DCD is applied in May and August because most losses occur between late autumn and early spring

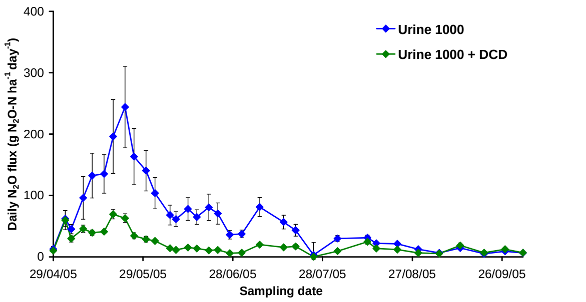


DCD reduced N_2O emissions by 73% on Templeton soil in Canterbury, NZ (Di et al. 2007).



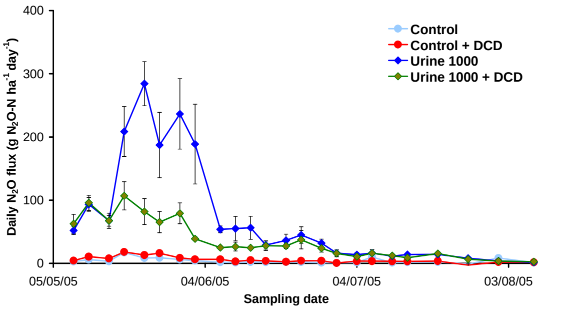
N_2O emissions reduced by 67% in the Canterbury Lismore soil

(Di et al., 2007)



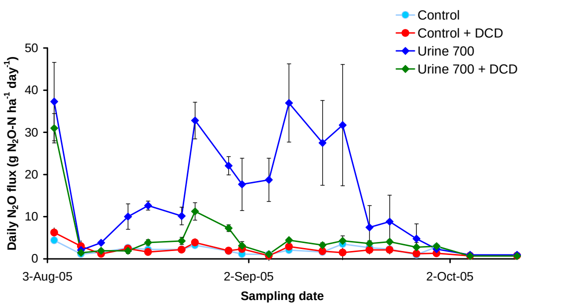
N_2O emissions reduced by 61% in the Waikato Horotiu soil

(Di et al., 2007)



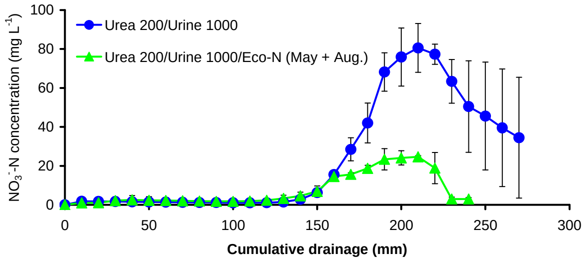
N_2O emissions reduced by 69% in the Taupo pumice soil lysimeters

(Di et al., 2007)

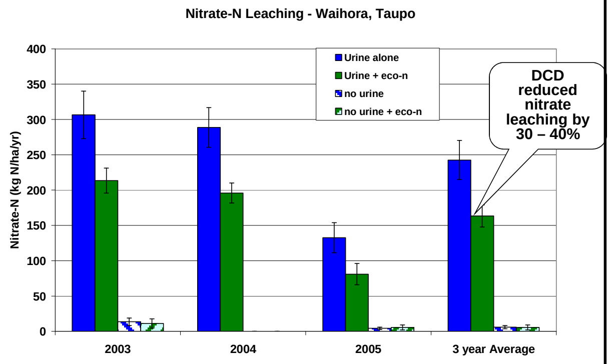


Nitrate leaching reduced by 76% from urine applied to Templeton soil

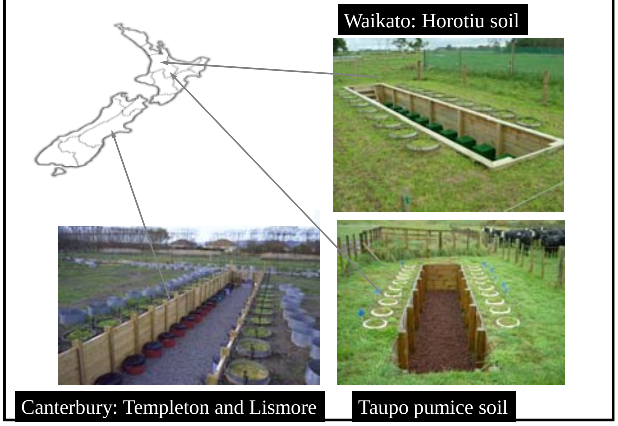
(Di and Cameron, 2004. NZ J Agr. Res. 47)



3 year trial shows that *DCD* inhibitor significantly reduced nitrate leaching losses from Taupo pumice soils



Soil lysimeter facilities in different regions



Internationally peer reviewed and published literature:

- Di, H.J., Cameron, K.C., 2002. The use of a nitrification inhibitor, dicyandiamide (DCD), to decrease nitrate leaching and nitrous oxide emissions in a simulated grazed and irrigated grassland. *Soil Use and Management* 18, 395-403.
- Di, H.J., Cameron, K.C., 2003. Mitigation of nitrous oxide emissions in spray - irrigated grassland by treating the soil with dicyandiamide, a nitrification inhibitor. *Soil Use and Management* 19, 284-290.
- Di, H.J., Cameron, K.C., 2004a. Effects of the nitrification inhibitor dicyandiamide on potassium, magnesium and calcium leaching in grazed grassland. *Soil Use & Management* 20, 2-7.
- Di, H.J., Cameron, K.C., 2004b. Treating pasture soil with a nitrification inhibitor, eco-nTM, to decrease nitrate leaching in a deep sandy soil under spray irrigation - a lysimeter study. *New Zealand Journal of Agricultural Research* 47, 351-361.
- Di, H.J., Cameron, K.C., 2004c. Effects of temperature and application rate of a nitrification inhibitor, dicyandiamide (DCD), on nitrification rate and microbial biomass in a grazed pasture soil. *Australian Journal of Soil Research* 42, 927-932.
- Di, H.J., Cameron, K.C., 2005. Reducing environmental impacts of agriculture by using a fine particle suspension nitrification inhibitor to decrease nitrate leaching from grazed pastures. *Agriculture, Ecosystems and Environment 109*, 202-212.
- Di, H.J., Cameron, K.C., 2006. Nitrous oxide emissions from two dairy pasture soils as affected by different rates of a fine particle suspension nitrification inhibitor, dicyandiamide. *Biology and Fertility of Soils* 42, 472-480.

Some of the data required to develop an N_2O inventory consists of:

- Animal numbers
- N excreta
- Direct emission factors
  - – EF1 N_2O emitted from fertiliser
  - – $EF3_{PRP}$ N_2O emitted from urine and dung
- Indirect emission factors
  - – EF5 N_2O emitted from leached N

2006 IPCC guidelines for National Greenhouse Gas Inventories

For a mitigation to be included in an inventory we also must know:

- Animal numbers affected by mitigation tool?
- Changes in N excreted?
- Time period of the year mitigation tool works?
- Changes in direct emission factors ?
- Changes in indirect emission factors ?
- Verification?

Summary of international peer reviewed literature: DCD effect on direct N_2O emissions

- The reduction in direct N_2O emissions $EF_{3(PRP)}$ averaged 67% ± 6% (std dev. n=4.)

Summary of international peer reviewed literature: DCD effect on NO_3^- leaching

- The reduction in nitrate leaching $Frac_{(LEACH)}$ averaged 74% ± 4% (std dev. n=5.)

Calculating DCD emission factors (EF)

$$EF1' plusDCD' = (IPCC\ default\ EF1) - (IPCC\ default\ EF1 \times \frac{50\%}{100\%} \times \frac{5\ months}{12\ months}) = 0.0099$$

kg N_2O/kg fertiliser-N

$$EF3_{PRP}'\ plus\ DCD-n' = (IPCC\ default\ EF3_{PRP}) - (IPCC\ default\ EF3_{PRP} \times \frac{50\%}{100\%} \times \frac{5\ months}{12\ months}) = 0.0079$$

kg N_2O/kg excreta-N

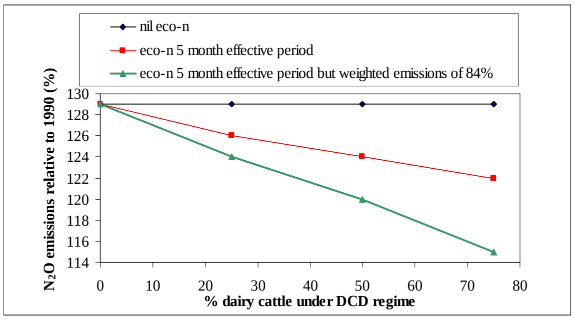
(Clough et al. 2007 Nutr. Cycl. Agroecosyst. 78:1-14.)

Table 8

Module	**2003 Agriculture (New Zealand)**				
Submodule	**Agricultural soils**				
Worksheet	**4.5 (3 of 5)**				
Sheet	**Direct nitrous oxide emissions from animal production (grazing animals)**				
Pasture, range and paddock AWMS	**N excretion for AWMS PRP (kg N)**	**Emission factor for AWMS ($EF_{3\ PRP}$) (kg N_2O-N/kg N)**	**Total direct animal prodn. emissions of N_2O-N (Gg)**	**Total direct animal prodn. emissions of N_2O (Gg)**	
PRP nil DCD	*1,386,897,313*	*0.0100*	*13.869*	*21.794*	
PRP plus DCD	*143,375,290*	*0.0079*	*0.836*	*1.314*	

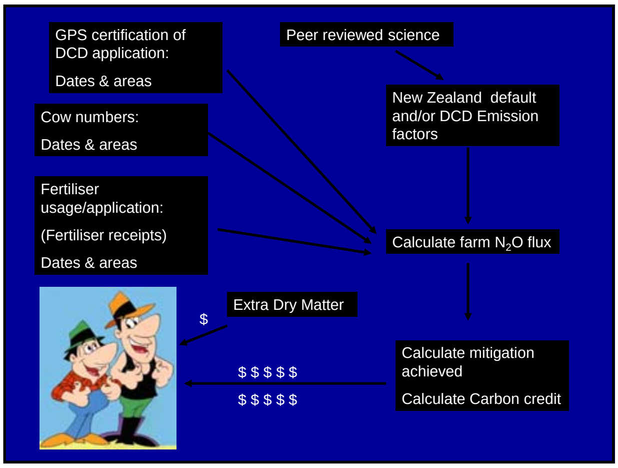
#Assumes 25% of dairy cattle under DCD regime

Effect of DCD on N_2O inventory



Verification ???

DCD application map – providing proof of placement



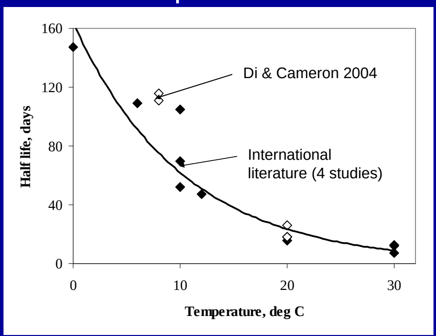
Summary

- Identify main N_2O sources and mitigation strategy.
- Peer reviewed science of mitigation tool.
  - Changes in N excreted?
  - Duration of mitigation effect(s)?
  - Changes in direct emission factors ?
  - Changes in indirect emission factors ?
- Verification.
  - Animal numbers affected by mitigation tool?
  - Land area affected by mitigation tool - Use technology! e.g. GPS.

DCD degradation and microbiology

- Soil bacteria utilise and degrade DCD.
- Numbers of nitrifiers not affected.
- N_2-fixers not affected by DCD.
- Repeat application of DCD in laboratory studies has little or no effect on rate of DCD decomposition or ability of DCD to inhibit nitrification.
- Moir et al. (2007, Soil Use & Mgt) shows no change in response to DCD after four years of field data collection in NZ.

DCD degradation and soil temperature



Kelliher & Clough et al. 2008

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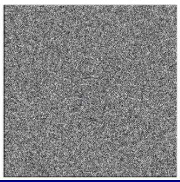
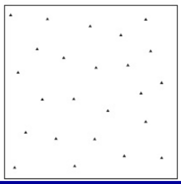
Eco-n **distribution.**



Eco-n supplies over 400 particles per square centimetre.

Scale – 20 cm x 20 cm = 400 cm^2

Granular product distribution.



Typically total surface area covered is less than 1% at 100kg per ha.

Scale – 20 cm x 20 cm = 400 cm^2

Nitrosomonas bacteria are widespread throughout the soil and <u>they all need to be treated.</u>