



## GHG Emissions: Challenges & Opportunities

Gary J. Lanigan

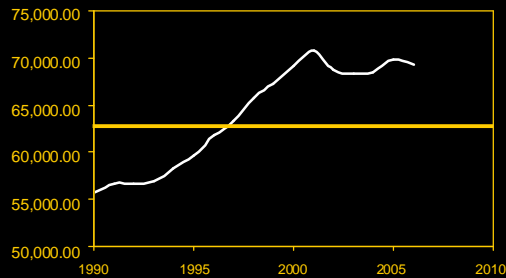
Johnstown Castle,  
Wexford

### GHG's & Global Warming Potentials

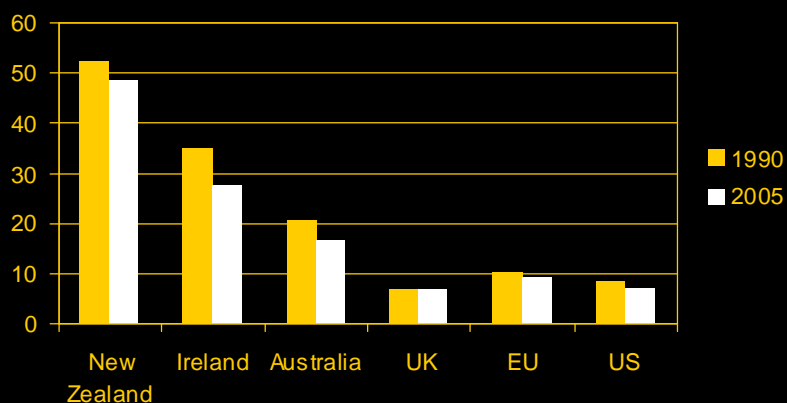
- Different GHG's have different capacities to induce radiative forcing.
- Measured in terms of CO<sub>2</sub>eq
- CO<sub>2</sub>:– GWP = 1
- CH<sub>4</sub>:– GWP = 21
- N<sub>2</sub>O:– GWP = 310
- HFC's, PFC's, SF<sub>6</sub> = 140 to 23,000

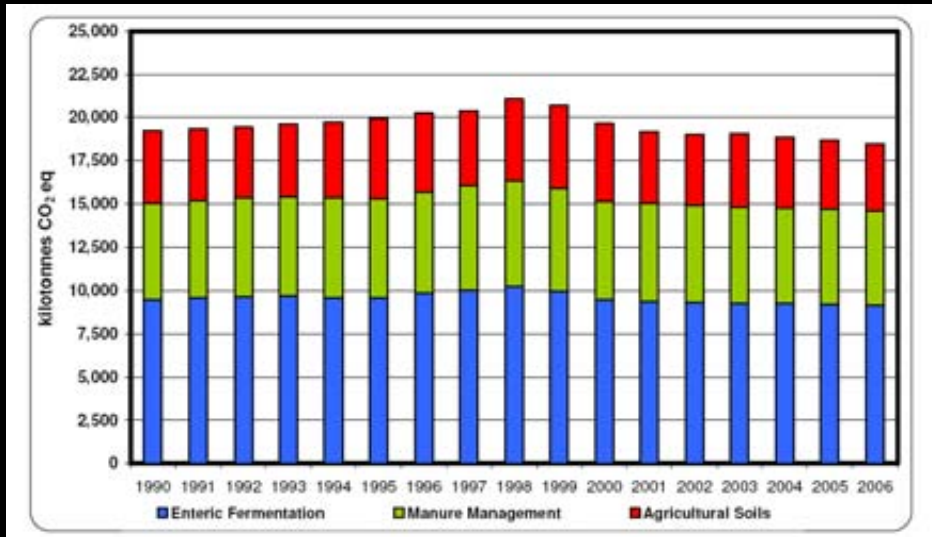
# Kyoto Protocol

- Sets targets for developed countries (Annex 1) to reduce GHG emissions by 5.2% by 2008-2012 compared with 1990.
- 8% reduction for EU as a whole (Decision 2002/358/EC)
- Irelands Target: +13% relative to 1990



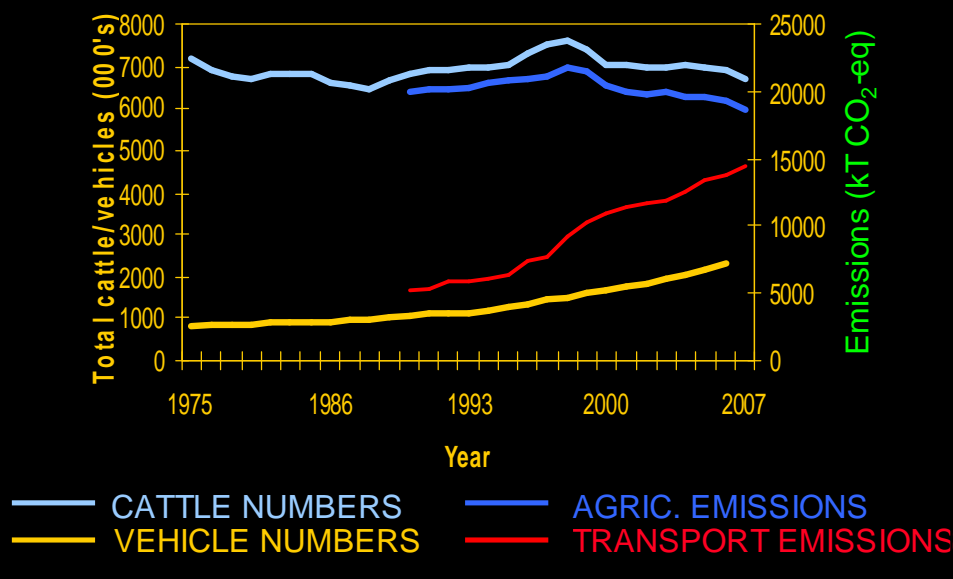
# Proportion of Agricultural GHG's by Country





Courtesy EPA, NIR 2008

### Trends in the Transport and Agricultural Sectors



## Future challenges

- Post Kyoto –
  - 20% from the non-ETS sectors *without* a global agreement
  - 30% *with* an agreement
- Agriculture will come under sustained pressure to reduce emissions in the medium term
- Impetus for increased production
- NZ/Australia are placing agriculture within national ETS
- GWP's will change (25 for CH<sub>4</sub>)

## Sub-Programme Research Objectives

1. Assessing CH<sub>4</sub> and N<sub>2</sub>O mitigation options/  
nutrient efficiency options  
*Set in the context of maintaining production potential*
2. Refining emission factors
3. Assessing impacts of land-use/land management change
4. Assessing the impacts on SOC
5. Elucidation of the processes that drive emissions and model development
6. Future climatic effects on emissions
7. Policy issues & financial consequences

## Mitigation strategies

1. Cost-benefit (Value of Carbon)
2. Monitoring & Verification (Measuring)
3. Permanence
4. Additionality and Leakage



## Value of carbon



## **Abatement strategies for methane emissions from beef and dairying**

- **Increasing grazing season**
- **Improving pasture digestibility**
- **Increasing clover in swards**
- **Replacing roughage with concentrates**
- **Reducing finishing times**
- **Increasing genetic merit**

## **Diet supplementation with oils**

- A 4% oil supplementation can reduce CH<sub>4</sub> by 23% per dairy cow (Beauchemin et al. 2008)
- Adding Coconut oil to concentrates can reduce finishing times by ~ 17 days (Foley)
- Importation of oils may negatively impact on the LCA of this strategy

## **Reducing Finishing Times**

- Moving from 34 to 24 month steers
- Lighter carcass but
  - Less concentrates, grass and silage
- Savings may outweigh revenue reduction

## Forage quality: Improved grass/more clover/maize silage

- Less fibrous forage results in a faster rate of passage and more propionate-type rumen fermentation
- Clover contains condensed tannins that can reduce CH<sub>4</sub>

However.....

- Maize cultivation has poor C balance
- How much clover is needed?

## Replacing roughage with concentrates

Concentrates (kg cow <sup>-1</sup> year <sup>-1</sup> )	736	1403
Kg CO <sub>2</sub> equiv./kg of milk	0.76	0.71
t CO <sub>2</sub> equiv./cow	5.79	5.86

Lovett et al. 2006

Finishing time reduction for beef cattle ~ 33 days

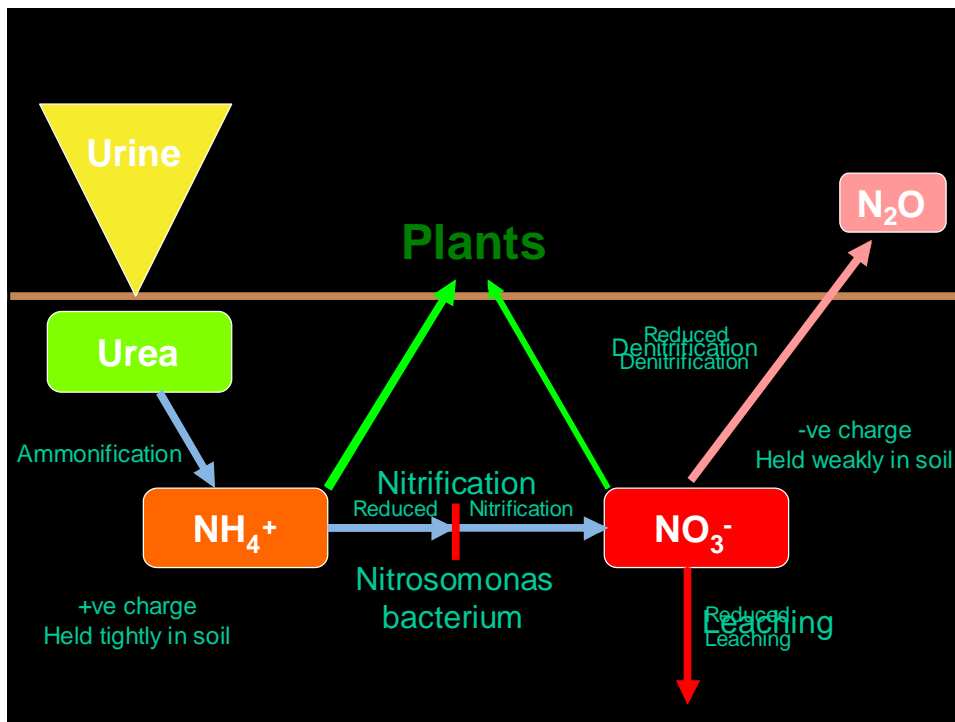
## Genetic merit

- Increases the amount of product per head
- Increased fertility = less replacements

## Manure management

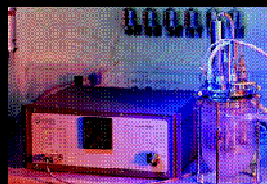
Aeration can reduce CH<sub>4</sub> by up to 25%.....but increased volatilisation





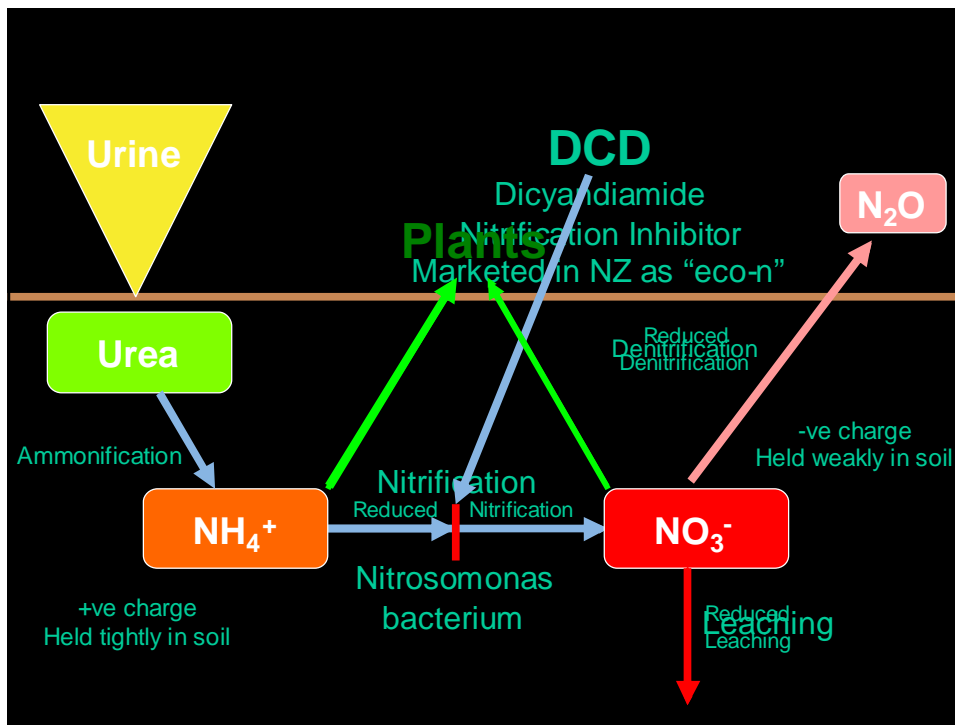
## N<sub>2</sub>O Research

- Reduction in N excreted from animals
- Nitrification (DCD) & urease inhibitors in pasture and tillage
- Clover pastures and extensive systems
- Increasing N efficiency:
  - Use of alternative land-spreading strategies, timing of fertiliser, amendment of slurries

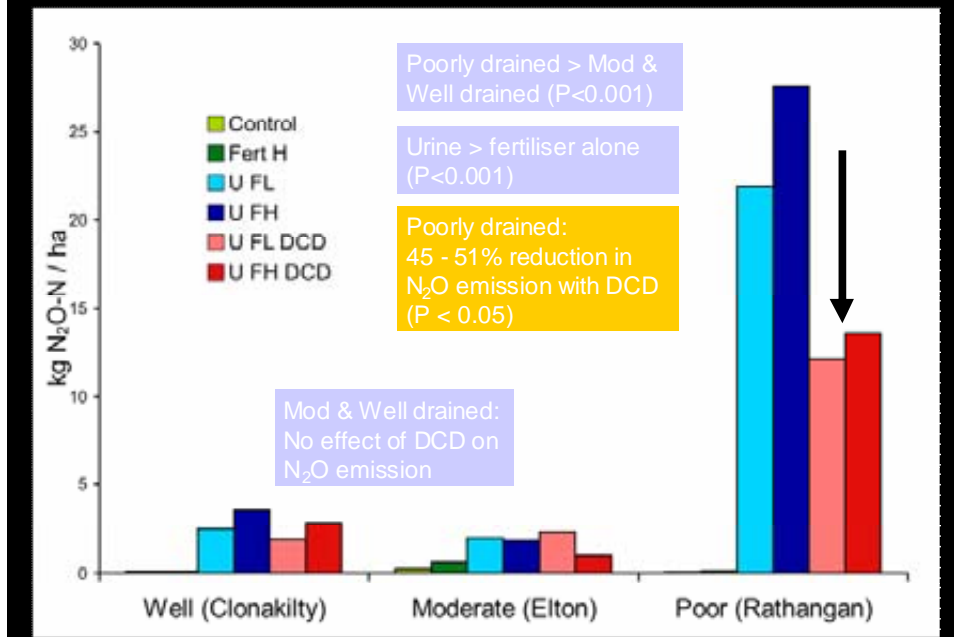


## Dietary Manipulation to increase N utilisation

- To establish the relationship between urinary N content and  $\text{NH}_3$ ,  $\text{N}_2\text{O}$  and  $\text{NO}_3$  emissions
- To investigate the effect of DCD addition on emissions from urine patches with variable N content.
- To upscale the urine patch results to field scale.
- Evaluate emission reduction by dietary manipulation

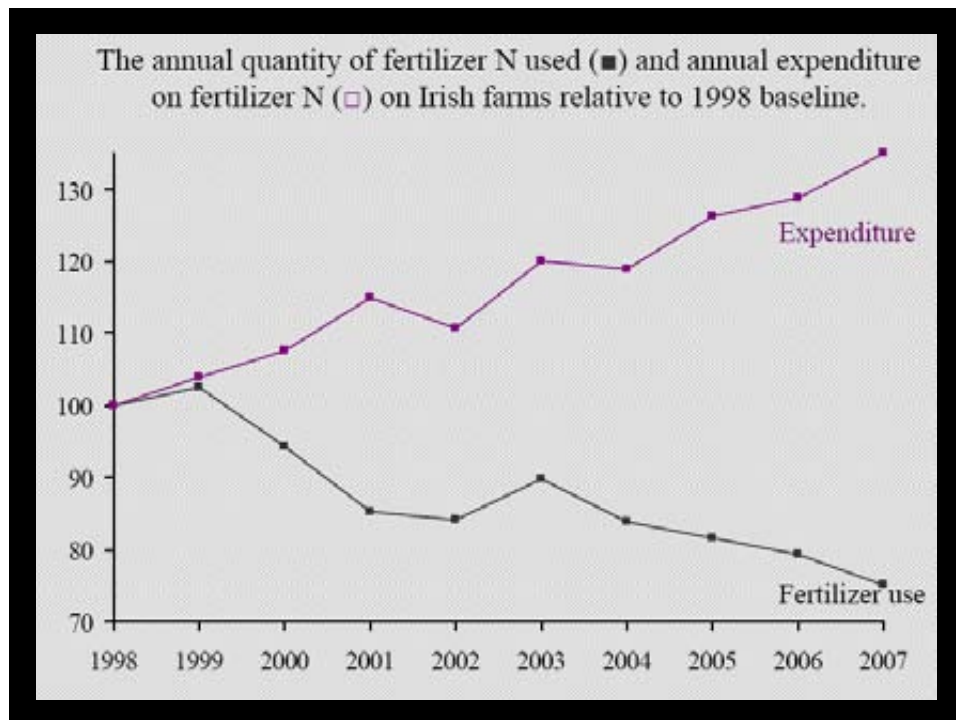


## Dennis & Richards 2008



## N efficiency

- Reducing ammonia volatilisation & GHG (landspreading and timing)/ Use of OWP's
- Switch to optimum size urea granules coupled with UI and NI
- Addition of slow release gels containing UI
- More efficient use of clover



## Clover

- Legumes fix atm. N reducing the need for inorganic N fertilizer
- Clover pastures may be effective at C sequestration



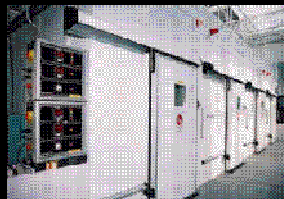
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2. Permanence
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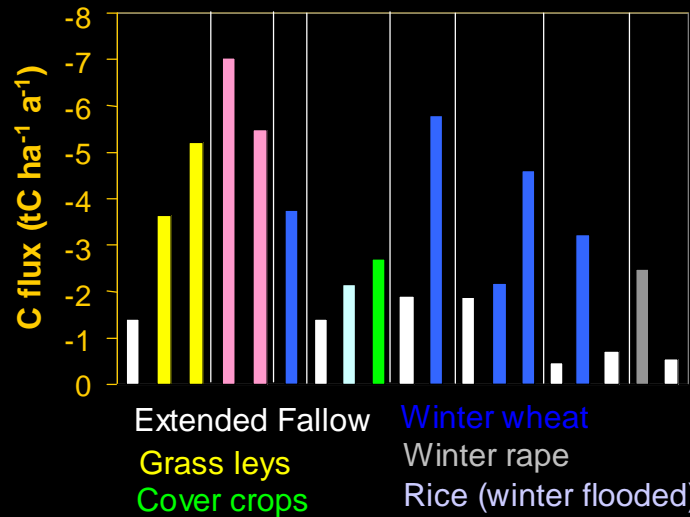


## Teagasc Research – C sequestration

- Tillage management: NIT, cover-crops, straw incorporation (0.1 to 0.15 Mt CO<sub>2</sub>-eq)
- Pasture management (0.05 – 0.1 Mt CO<sub>2</sub>-eq)
- Sequestration of C in soils *via* land-use change/forestry (3.5 – 5.0 Mt CO<sub>2</sub>-eq)
- Biomass crops (0.1 – 3 MT CO<sub>2</sub>-eq)



## Effect of crop rotation/winter cover on C sink activity

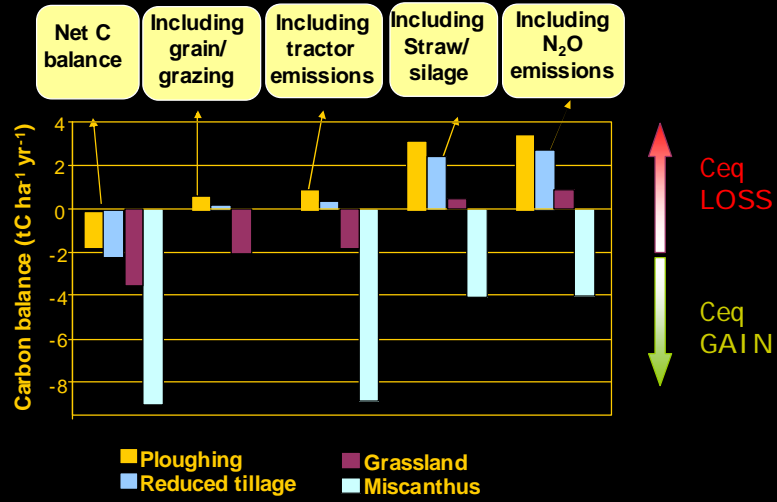


Lanigan et al. 2008

## Shifting pasture to biomass

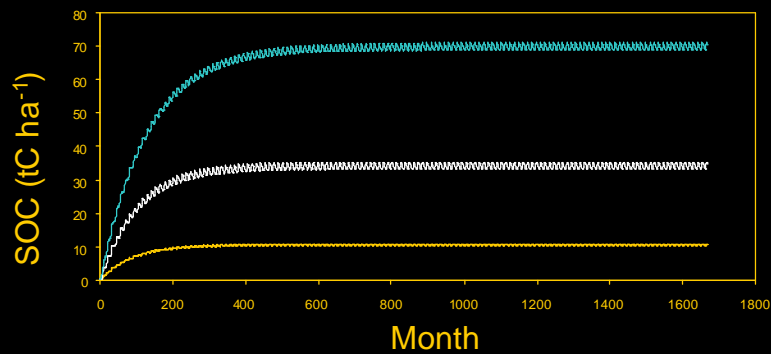
- Sequestration potential of perennial biomass crops could be high
- However SOC loss due to ploughing of pasture is high
- 30% Co-firing Target: Replacement of ~0.91 million tonnes of peat = 0.8 Mt CO<sub>2</sub>-eq
- Who gets the credits?

## Comparison of Land-Use and Land Management GHG Budgets



Davis et al. 2008

## Permanence: Land management effects on SOC

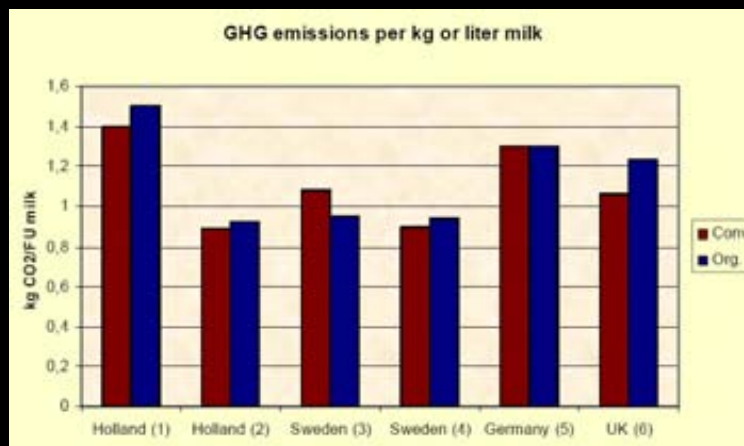


Conventional ploughing  
Non-inversion tillage  
Grassland

## Overarching Strategies

Inputs	Intensive REPS	
Fertiliser kg/ha	233	90
Concentrate feed kg/ha	31	25
N deposition kg/ha (Ryan et al 2006)	9	9
<b>Total Inputs kg/ha</b>	<b>272</b>	<b>124</b>
Outputs		
Animal liveweight gain kg/ha	12	10
ammonia volatilisation kg/ha	48	48
denitrification (kg/ha) IPPC 1.25% N fert	3	1
leaching kg/ha	21	6
<b>Total Outputs kg/ha</b>	<b>84</b>	<b>65</b>
N not accounted for (input - output)	189	60

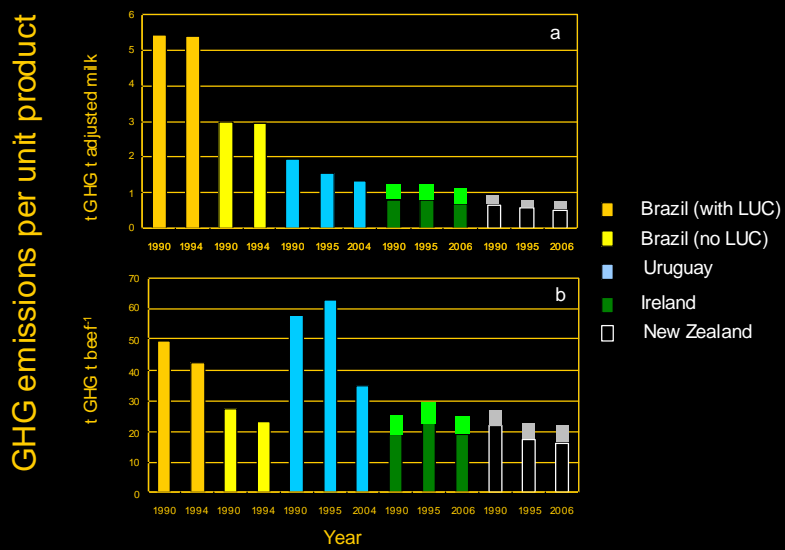
## GHG Budget: Conventional vs. organic



De Boer (2003) Livestock Prod. Sci 80

# Leakage

## GHG emissions per product



## Conclusions

- A mosaic of solutions – no ‘magic bullet’
- Farm-scale integrated approach to finding solutions
- Improved production per unit animal/hectare
- Require a mechanism to input abatement strategies into national inventories

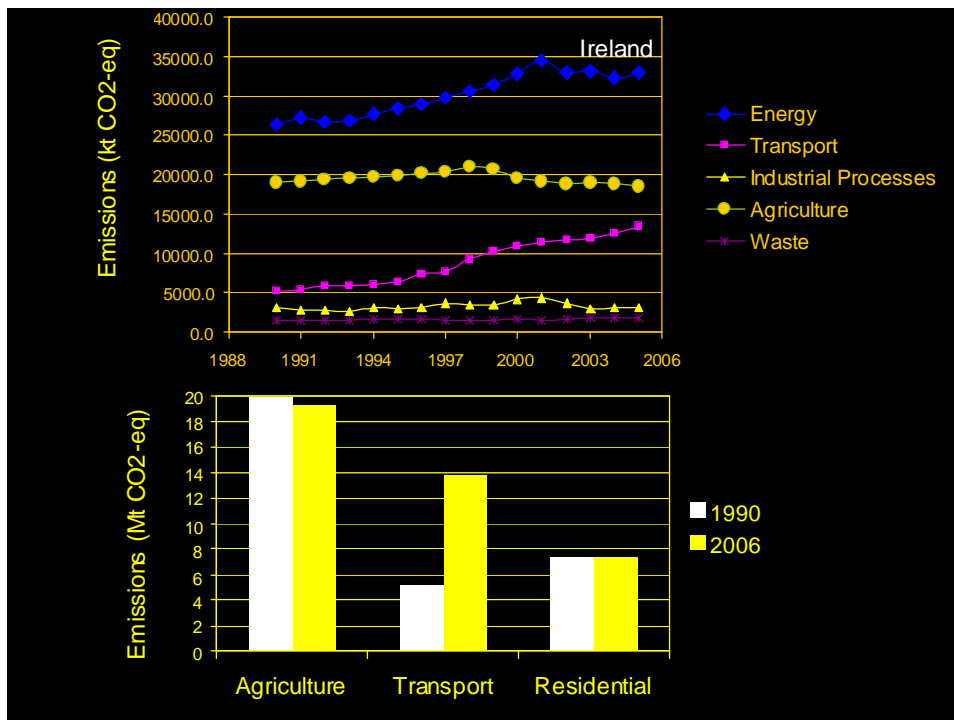


## Tillage Management



## Tillage

- Can different management practices increase C sequestration: Conventional tillage and Non Inversion Tillage.
- Management factors for enhancing C sequestration in agricultural ecosystems involve increasing crop residue inputs and decreasing soil organic matter (SOM) decomposition.

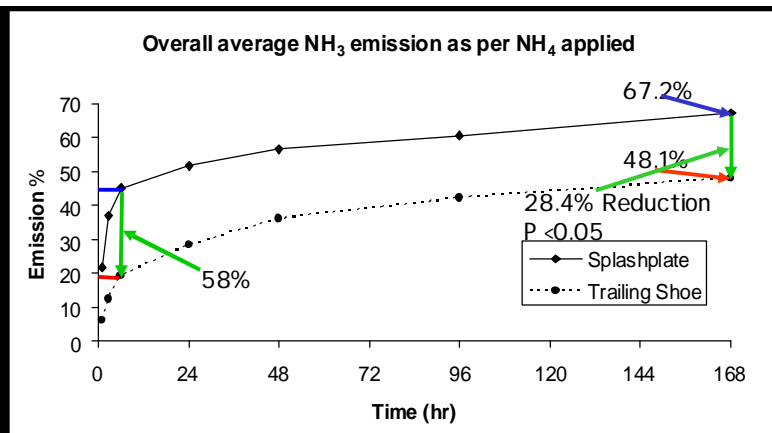


## Relevance to agriculture

- Under Kyoto, 'Sinks' can be counted towards meeting targets.
- Absorption by sinks to be measured as verified changes in carbon stocks.
- Count net removals of carbon by afforestation, reforestation and deforestation (Article 3.3)
- Other activities, known as 'additional human-induced' (those relating to agricultural soils, land-use change and forestry) may be included. (Article 3.4)
- Default values are unfavourable to Irish tillage

## Ammonia abatement

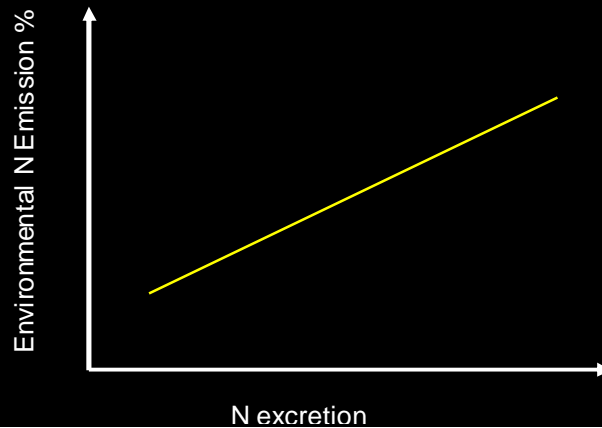
- Land-spreading techniques (trailing shoe vs. splashplate)
- Spring vs. summer application
- Addition of slow release gels containing UI



- Consistently lower emissions associated with trailing shoe (average reduction = 28.9%)
- Lower emissions associated with early spreading for both application techniques.
- Emissions from OWP per LU are 25% lower compared to slatted sheds

## Dietary Manipulation to increase N utilisation

Objective: Model to predict environmental emissions at a range of urinary N contents



## Changing Agricultural Practices Can Produce GHG Offsets in 2 Ways

### Reduce Direct GHG

#### Emissions:

- Precision **nitrogen fertilizer use** reduces  $N_2O$  and  $CO_2$
- **Inhibitors** and **diet manipulation** can reduce lower  $N_2O$  emissions
- **Clover** can reduce fert. inputs
- **Fuel use** reductions lower  $CO_2$  emissions
- **Biofuel** reduces use of  $CO_2$ -intensive fossil fuels

### Sequester Carbon:

- No or low **tillage**
- Diversified **rotations**
- Winter **cover crops**
- Change **soil inputs**
- Improved **grazing** practices
- **Convert** marginal agricultural land to grassland or forest

# Future challenges

