Nitrogen efficiency and environmental footprinting of agricultural products

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agresearch NEW ZEALAND LIFECYCLE MANAGEMENT CENTRE

Outline of talk

1. Farm & paddock level:
   - -N cycling and losses
   - - Reducing N leaching
   - - new N mitigations?
2. Value-chain/life-cycle level:
   - - carbon and N footprinting
   - - where is this heading?

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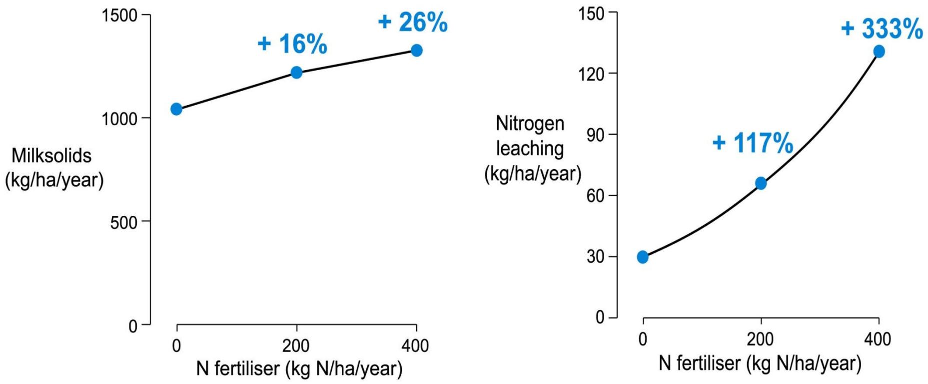
Effect of N fertiliser rate (5 years; No. 2 dairy)



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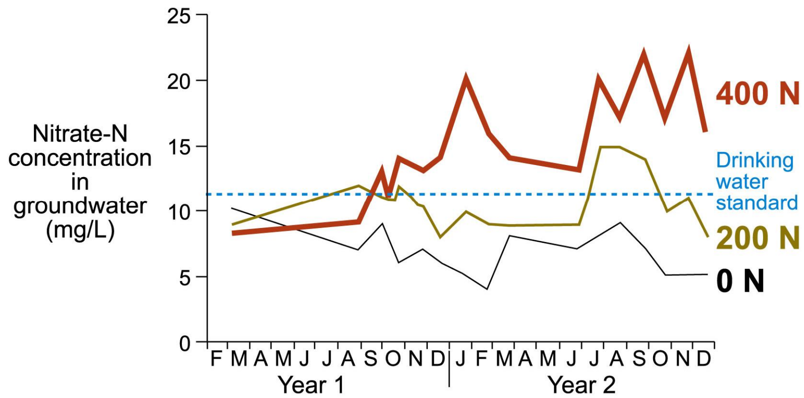

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Farmlets: Intensification & mitigation

	Base	+Maize silage (5 t DM/ha)	+Stand-off (May-July; 18h/day)
Cows/ha	3.0	3.8	3.0
kg milksolids/ha/yr	1150	1520	1110
kg N leaching/ha/yr	41	44	33
N leaching for farm+maize area		[49]	

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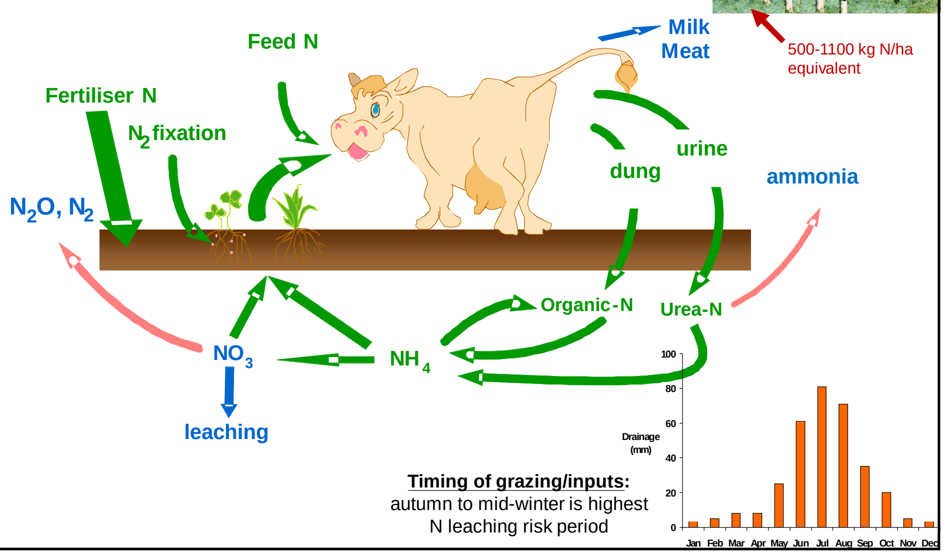
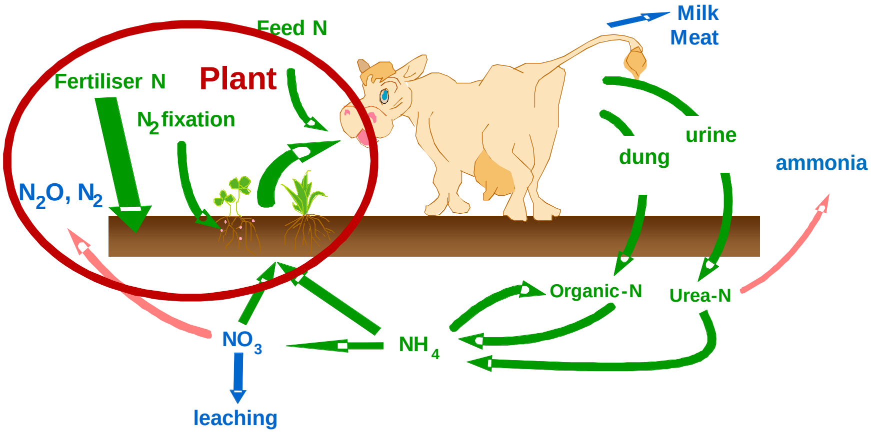
Nitrogen cycling and losses

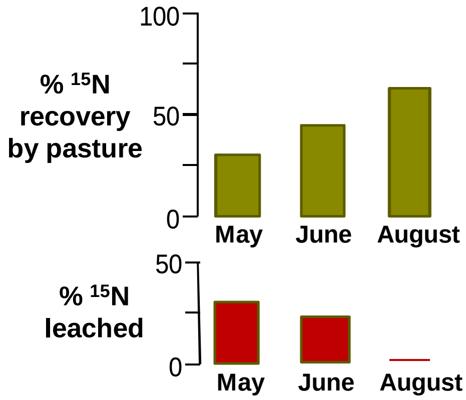


Nitrogen cycling and losses

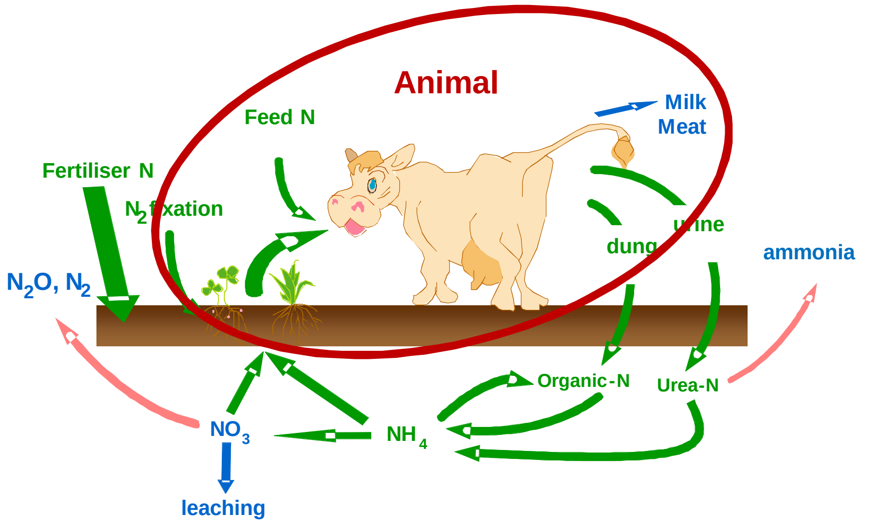


Nitrogen use efficiency (% recovery of N input source)

	Actual	Potential	Theoretical
Plant:			
Fertiliser N	40-60%	60-70%	80-90%



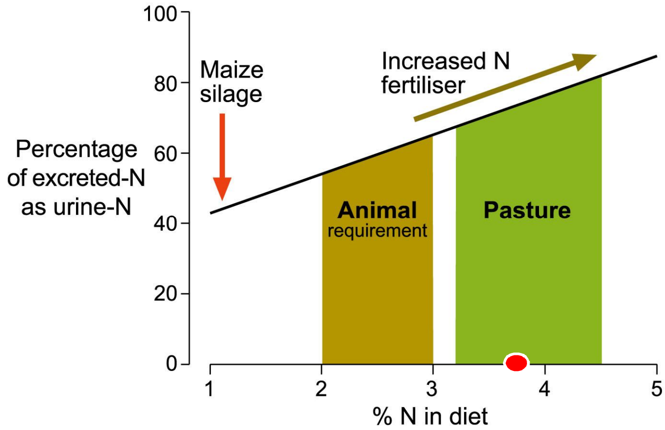
Nitrogen cycling and losses



Nitrogen use efficiency (% recovery of N input source)

	Actual	Potential	Theoretical
Plant:			
Fertiliser N	40-60%	60-70%	80-90%
Animal **(milk+meat+fibre)**:			
Feed N	10-20%	20-30%	40%
NZ average (dairy)	~18%		

Diet %N



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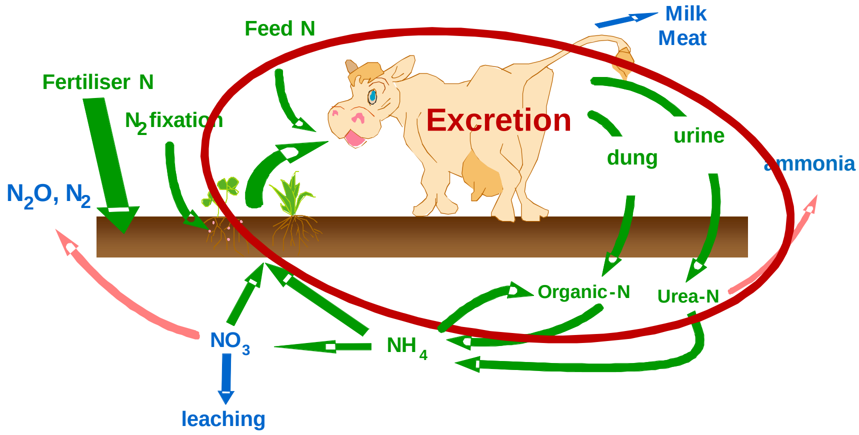
NZ average (dairy)	~18%		
Hawkes Bay Dairies	30%		

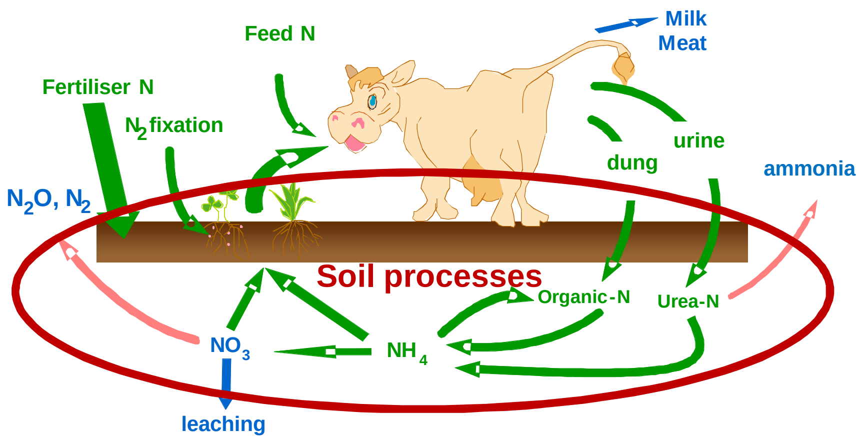
Nitrogen cycling and losses



Nitrogen use efficiency (% recovery of N input source)

	Actual	Potential	Theoretical
Plant:			
Fertiliser N	40-60%	60-70%	80-90%
Urine N	20-40%	40-60%	80-90%
Animal (milk+meat+fibre):			
Feed N	10-20%	20-30%	40%

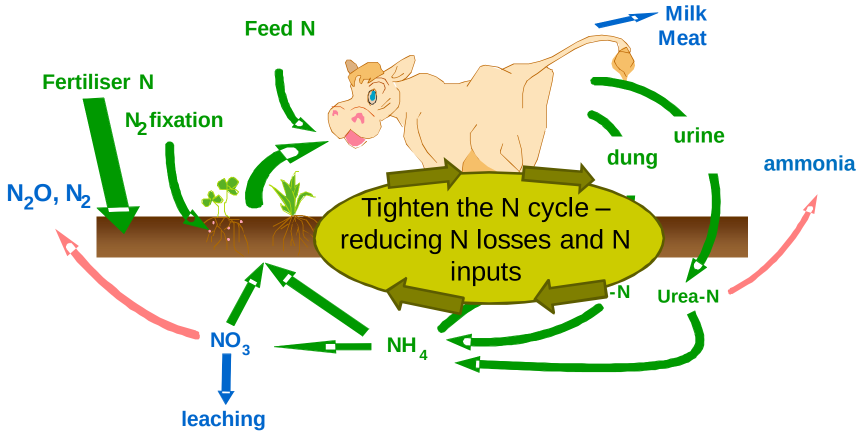
Nitrogen cycling and losses



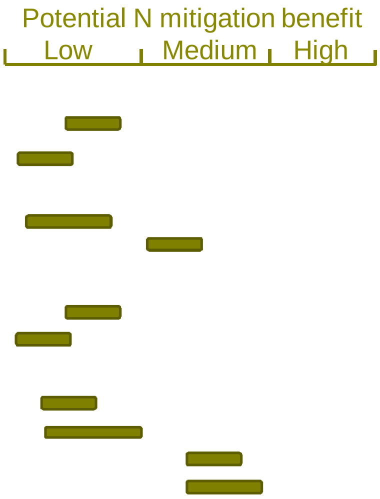
Nitrogen use efficiency (% recovery of N input source)

	Actual	Potential	Theoretical
Plant:			
Fertiliser N	40-60%	60-70%	80-90%
Urine N	20-40%	40-60%	80-90%
Inhibitors – urine N	*30-50%*	*60-70%*	*80-90%*
Animal **(milk+meat+fibre)**:			
Feed N	10-20%	20-30%	40%

Nitrogen cycling and losses



Most current mitigations now captured in models



N fertiliser:
- avoid winter
- frequent, low rates

Feed:
- use low-N feed
- ↓ N fert, ↑ low-N feed

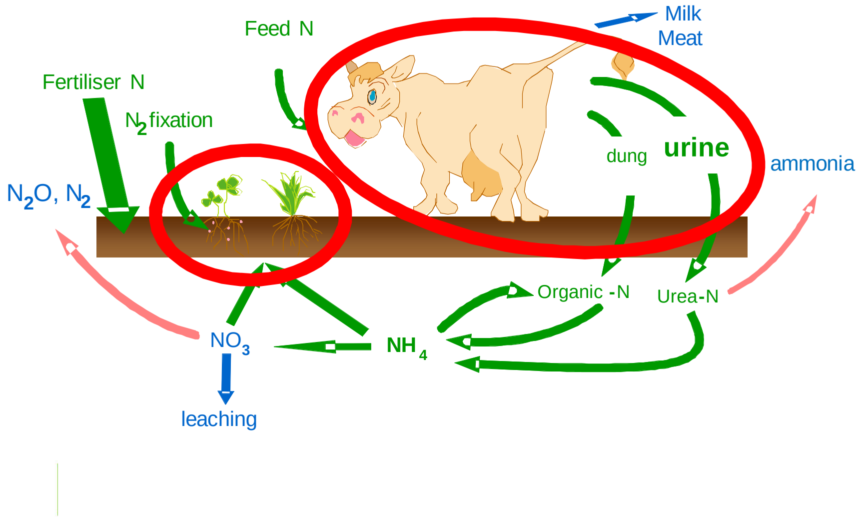
Animal productivity:
- > MS/cow & less cows
- ↓ replacement rate

Effluent management:
- ↑ area,
- optimise rate/timing

Inhibitors: - DCD

Stand-off pad use

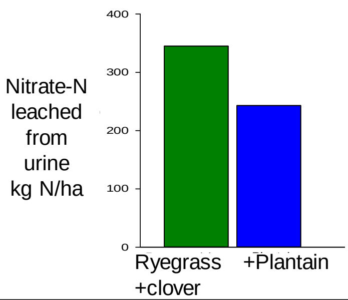
Next-generation N leaching mitigations for grazed systems?



Next-generation N leaching mitigations for grazed systems?

1. **Plant level**

- root capture of urine-N
- lower %N in leaves
- composition – less N excreted in urine
  – alter soil N process e.g. slowed nitrification



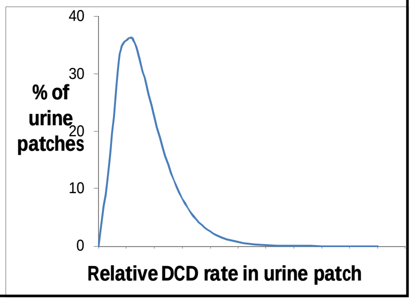
Next-generation N leaching mitigations for grazed systems?

2. Strategically targeting animal urination

- additive to alter urine N processes in soil

e.g. DCD (soil nitrification inhibitor) direct to animal

- use ~ 1/10th that of broadcasting
- 70-90% excreted in urine



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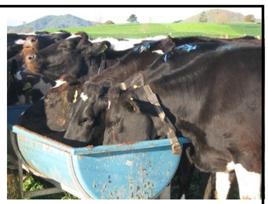
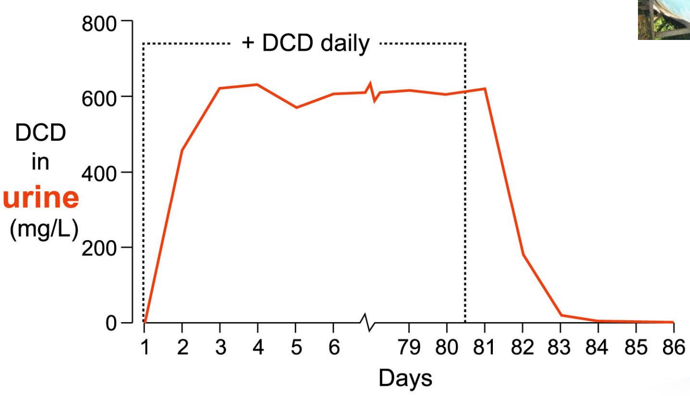
DCD in urine via grazing animal





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Next-generation N leaching mitigations for grazed systems?

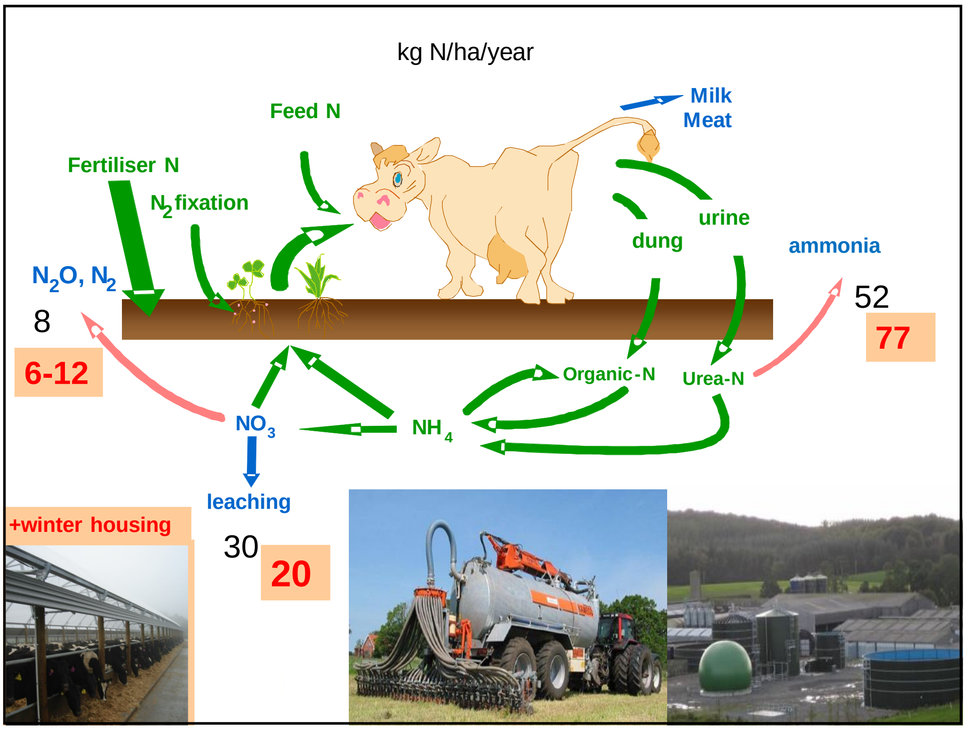
2. Strategically targeting animal urination

- additive to alter soil N processes
- additive/manipulation to increase urination frequency

e.g. salt

- increased water intake
- > urination frequency – up to 50%
- lower urine-N rate and proportionally lower N leaching
- up to 20% lower N leaching/ha (via modelling)

Housing to reduce N losses?



Nitrogen pollution swapping

Ammonia loss:

Europe – National Ceilings Directive & Gothenburg Protocol

(eutrophication, acidification, respiratory/health)

– reduction targets e.g. -27% relative to 2005

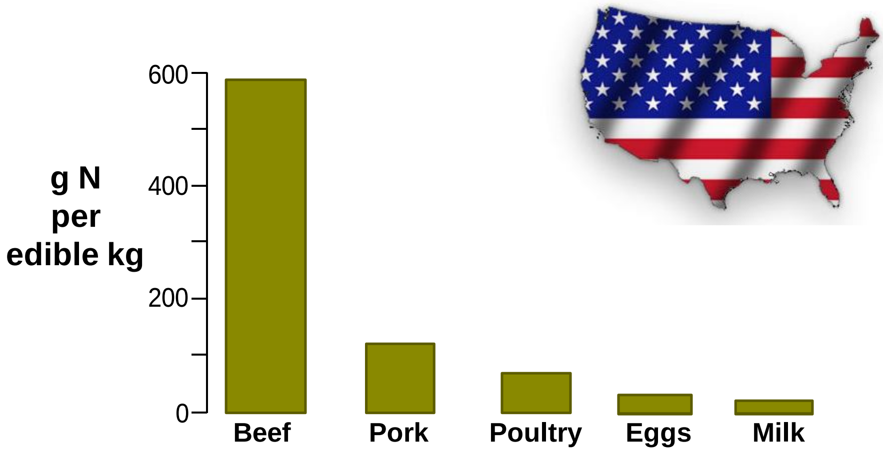
Ireland - looking at mitigations

e.g. reduce housing & increase grazing time !

Nitrogen losses and impacts:

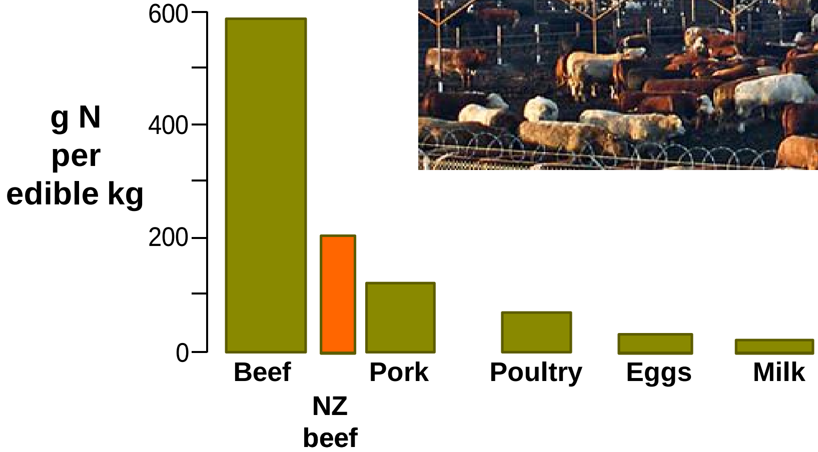
'Reactive' N sources	*Environmental impact*
NO_3^- & N to water	Eutrophication
NH_3 , NO_x	Acidification
NH_3 , NO_x	Human health
N_2O (NO_3^- & NH_3 indirect)	Climate Change
N_2O	Ozone depletion

N footprint of products from USA (at farm-gate)



Eshel et al. 2014

N footprint of products



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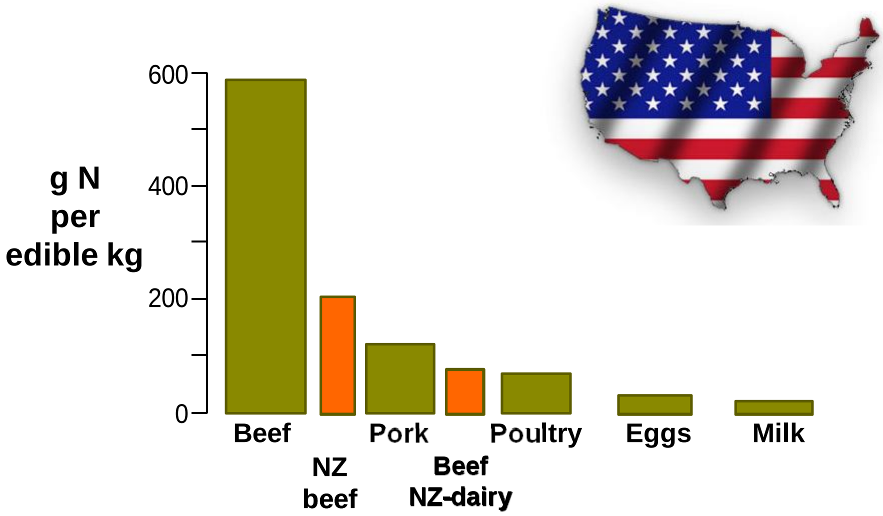
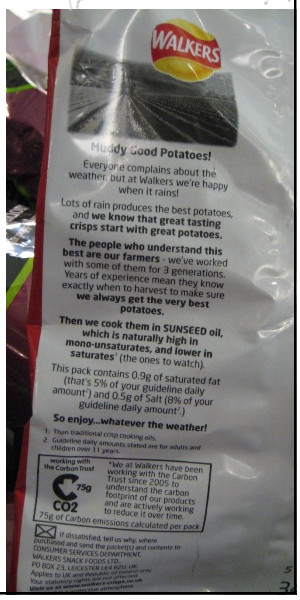


Eshel et al. 2014

Global value-chain level

What is the environmental impact of products we buy?



Driven by supermarket chains:

Demand for information for consumers

- UK supermarket chains
- France, South Korea… - *Eco-labelling*
- Becoming a supply requirement
  - with an environmental reduction plan

Government level: Indirectly via goals for reducing global GHG emissions

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LIFE CYCLE ASSESSMENT

Total resource use or environmental emissions of a product or system from "cradle-to-grave"

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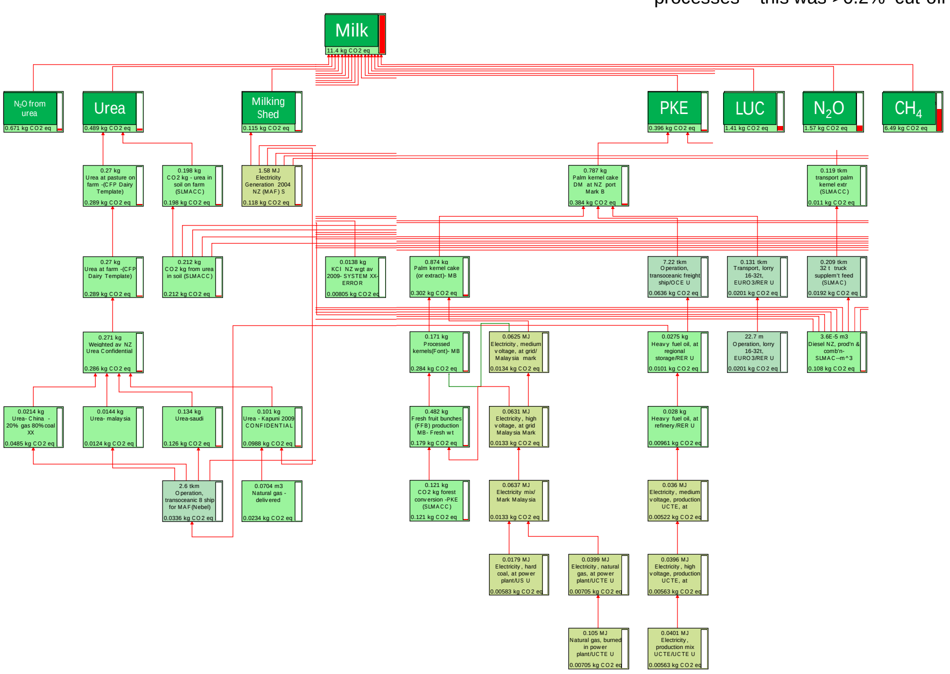
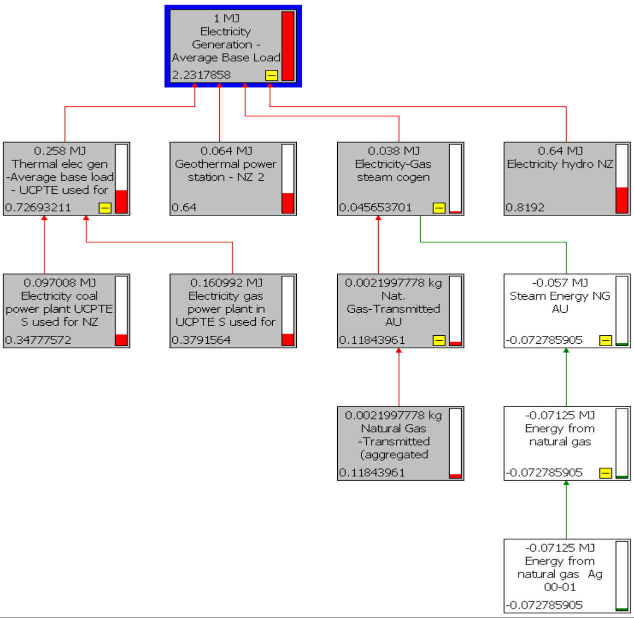
Based on international standards (e.g. ISO 14040s norms; PAS 2050)

Example of LCA network (1 kg milk)

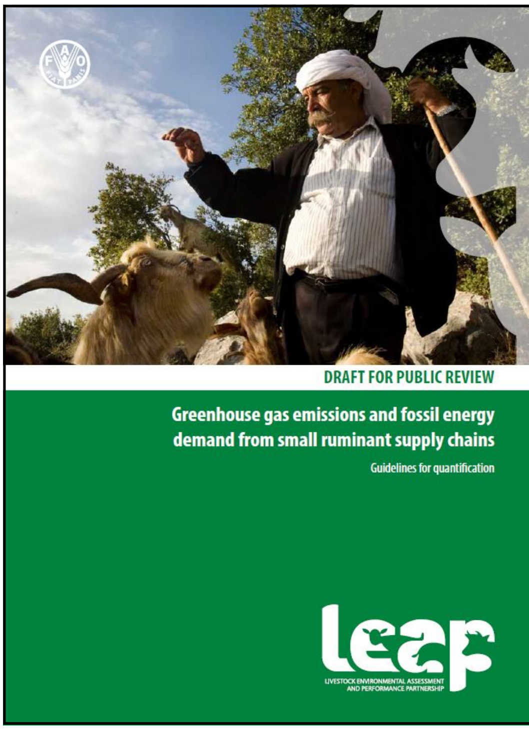
Network shows many hundreds of processes – this was >0.2% 'cut-off'



Example of LCA network (1 MJ electricity)

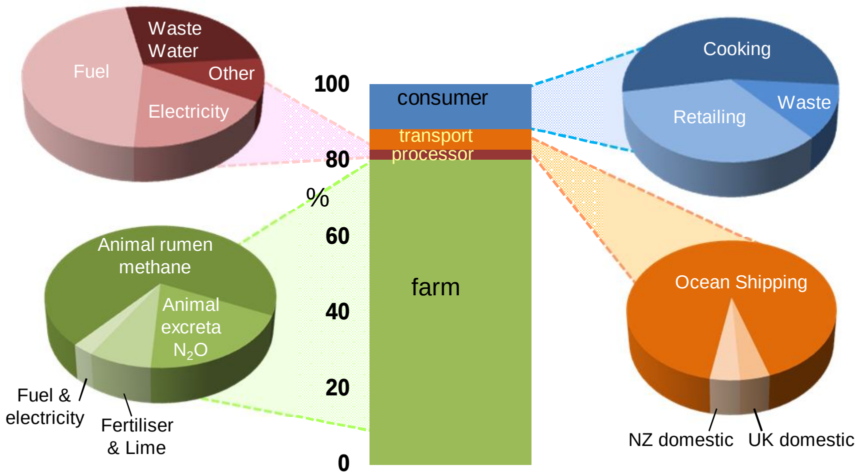


Carbon footprint



Internationally accepted methodology is important

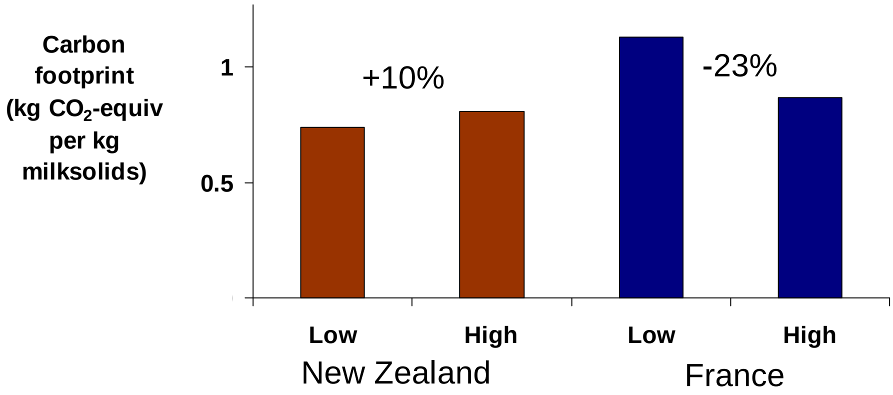
- Benchmarking
- Determine 'hot-spots'
- Identify reduction opportunities



19 kg CO_2-equiv./kg meat

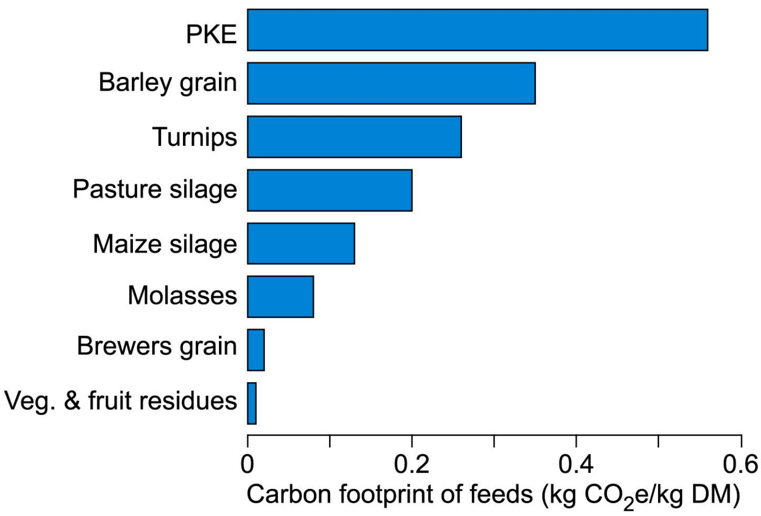
Sensitivity analyses:
e.g. inclusion of consumer travel gave increase of up to 7%

Effects of dairy intensification in NZ and France through increased use of supplementary feeds



	NZ Low	NZ High	France Low	France High
cows (or LU)/ha →	2.8	2.8	1.6	1.4
kg milksolids/cow→	326	422	424	610

Carbon footprint of supplementary feeds



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Future use of Life cycle assessment?

Eco-Design

- Optimise current systems

  and

- Use in redesigning future farm systems

  for – resource use efficiency and
  low environmental impacts
  (avoiding "pollution swapping")

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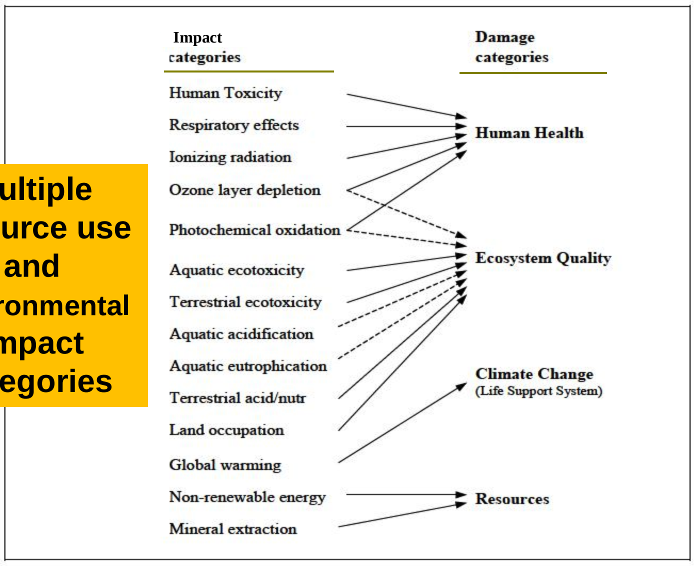
What's the latest in environmental footprinting?

EU Product Environmental Footprinting

Multiple resource use and environmental impact categories



Summary

Farm N efficiency:

- Gains require focus on annual N flows to decrease N losses PLUS corresponding decrease in N inputs
- Next-generation N mitigations for grazed pastures:
  - Plant species and traits
  - Strategically targeting animal urination
- N pollution swapping occurs *e.g. with cow housing*

Life cycle environmental footprinting:

- Driven by supermarket chains & government targets
- Potential for reduction throughout the life cycle
- For livestock products, the farm stage dominates
  - Management practices & feed types are important

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