ALTERRA
GREEN WORLD RESEARCH

AGRICULTURE AND NITROGEN; WHAT GOES IN MUST COME OUT

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Outline

- Agriculture and N flows
- Pollution swapping in EU-25+
  - NH_3 emission abatement measures
  - NO_3 leaching abatement measures

Agricultural Systems

- **Crop production systems**
  - Arable crops
  - Vegetables & fruits & flowers
  - Greenhouse systems

- **Animal production systems**
  - Grazing systems
  - Mixed systems
  - Land-less or foot-loose systems (industrial)

Huge diversity in crop production

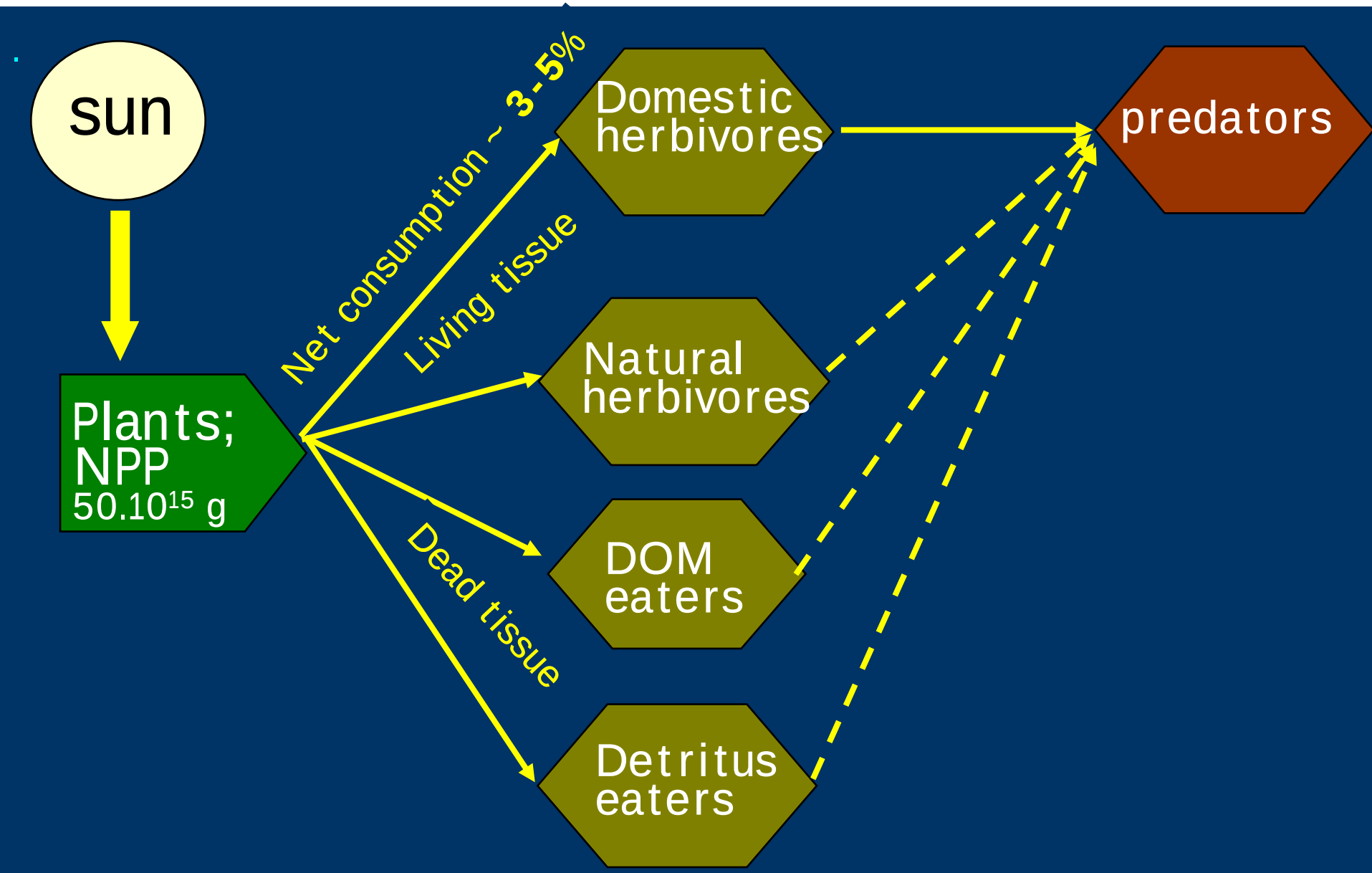






Huge diversity in animal production

Agriculture and net primary production



Current share of Agriculture to global flows

- *NH_3 emissions~ 90%*
- *N_2O emissions~ 50%*
- *CH_4 emissions~ 20%*

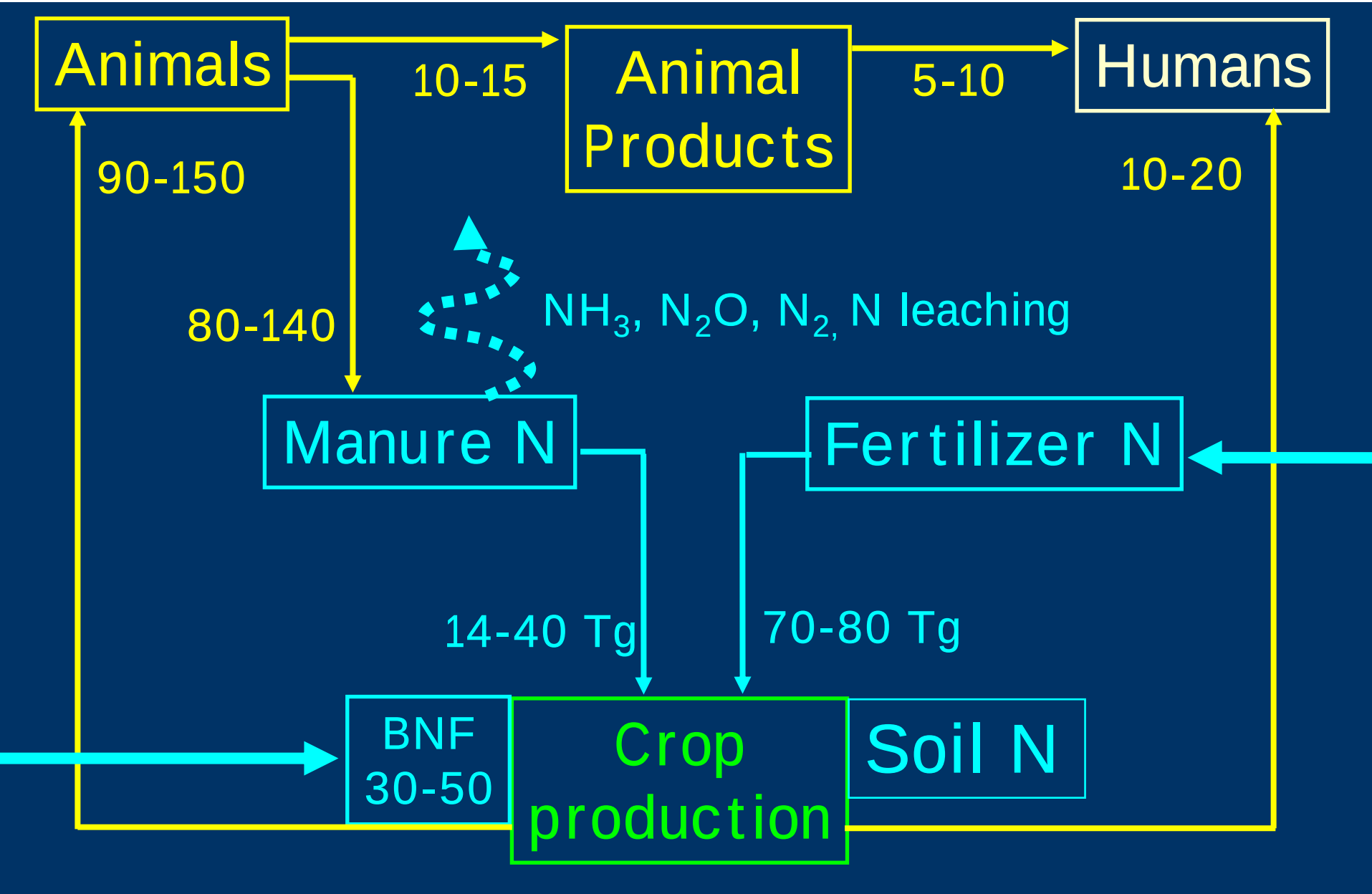
} Much related to animal production

- *N excretion ~ 1.2 x N fertilizer production*
- *P excretion ~ 1.5 x P fertilizer production*
- *K excretion ~ 3 x K fertilizer production*

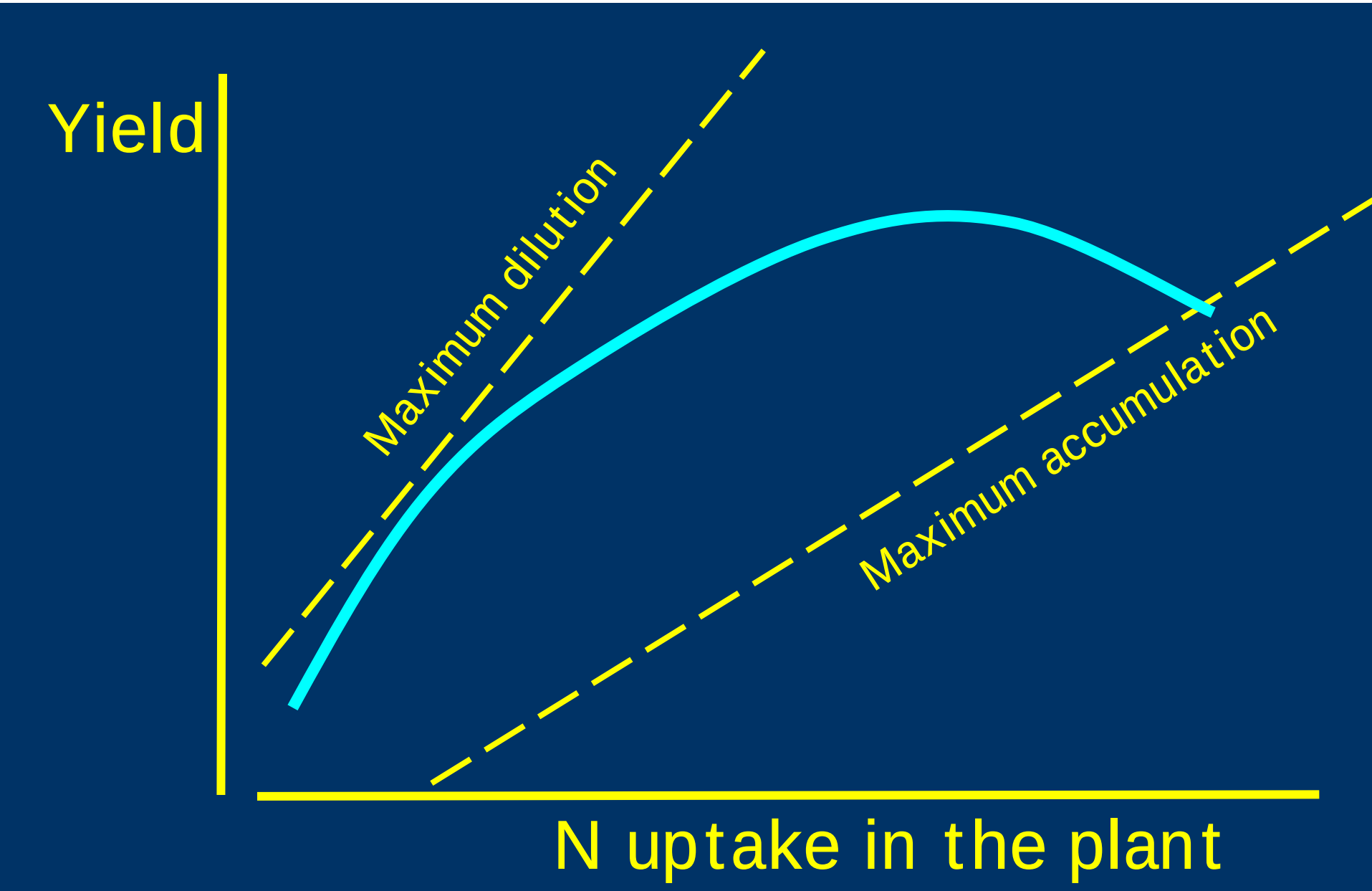
Partitioning of NH_3 sources in Agric.

- *Animal housing* *20-40%*
- *Manure application* *20-30%*
- *Grazing animals* *10-20%*
- *NH3-based fertilizers* *10-20%*
- *Other sources* *5-10%*

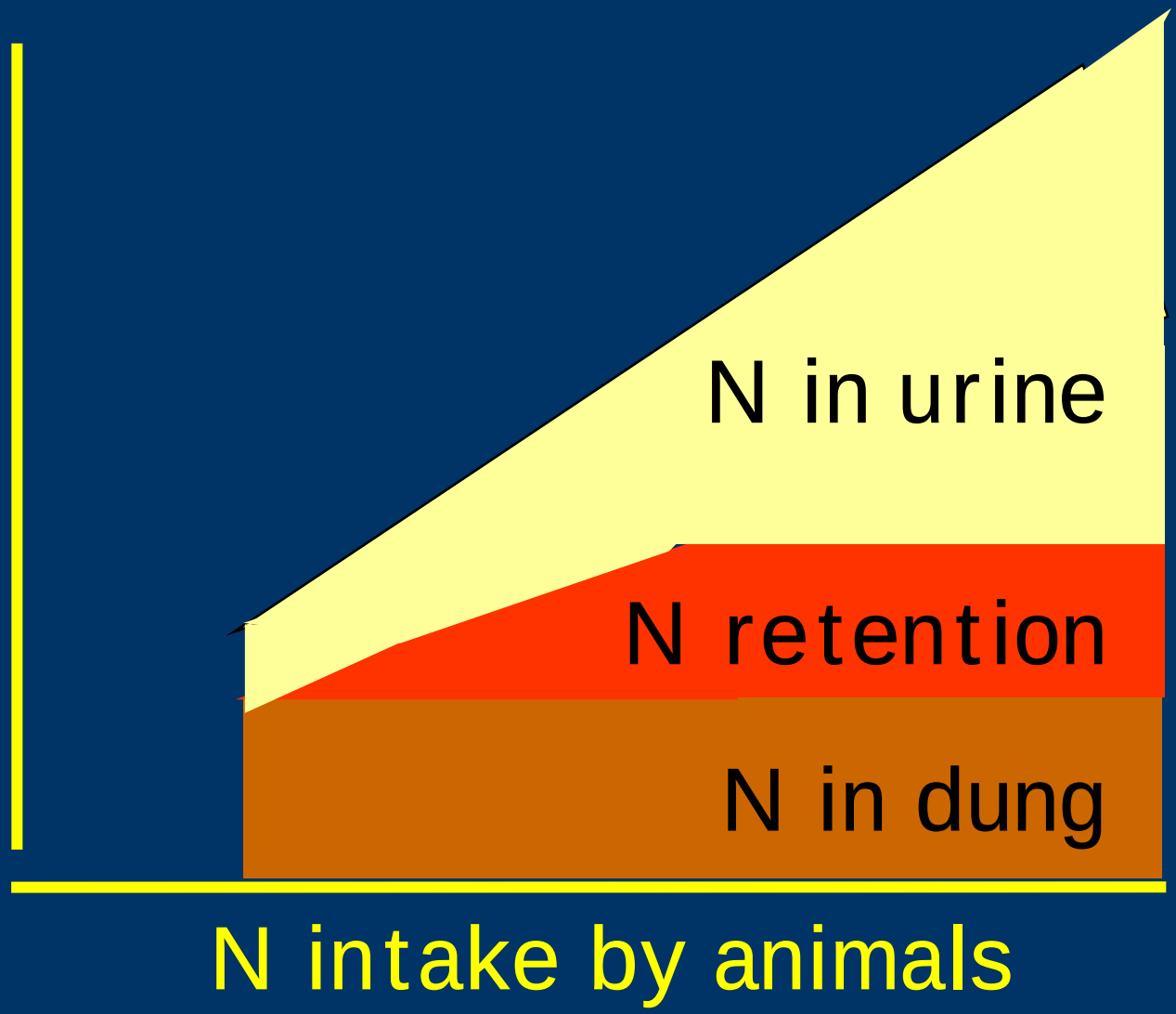
Global N cycle



Crop yield at harvest and N uptake



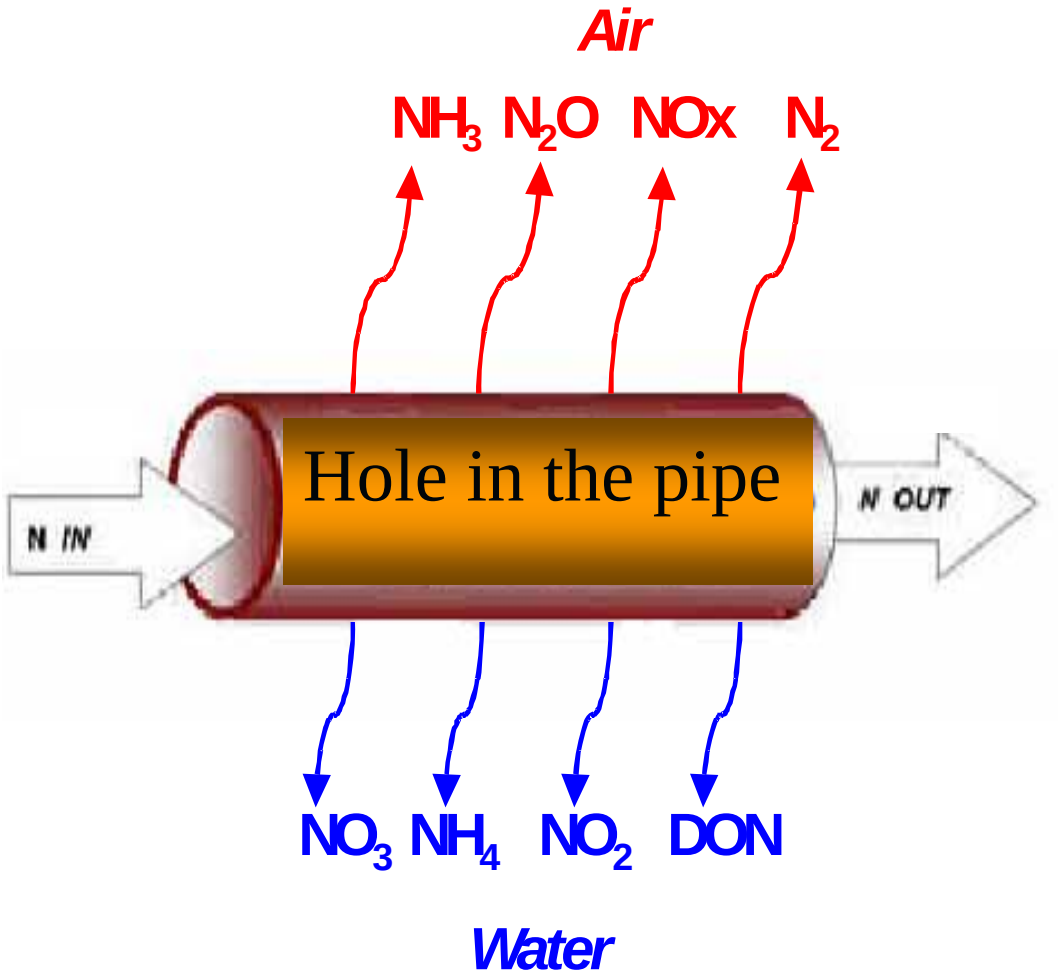
N intake, retention and excretion by animals



Agriculture & nitrogen: what goes in must come out

N INPUTS

(e.g. manure, fertiliser, etc.)



N OUTPUTS

(e.g. crops, meat, etc.)

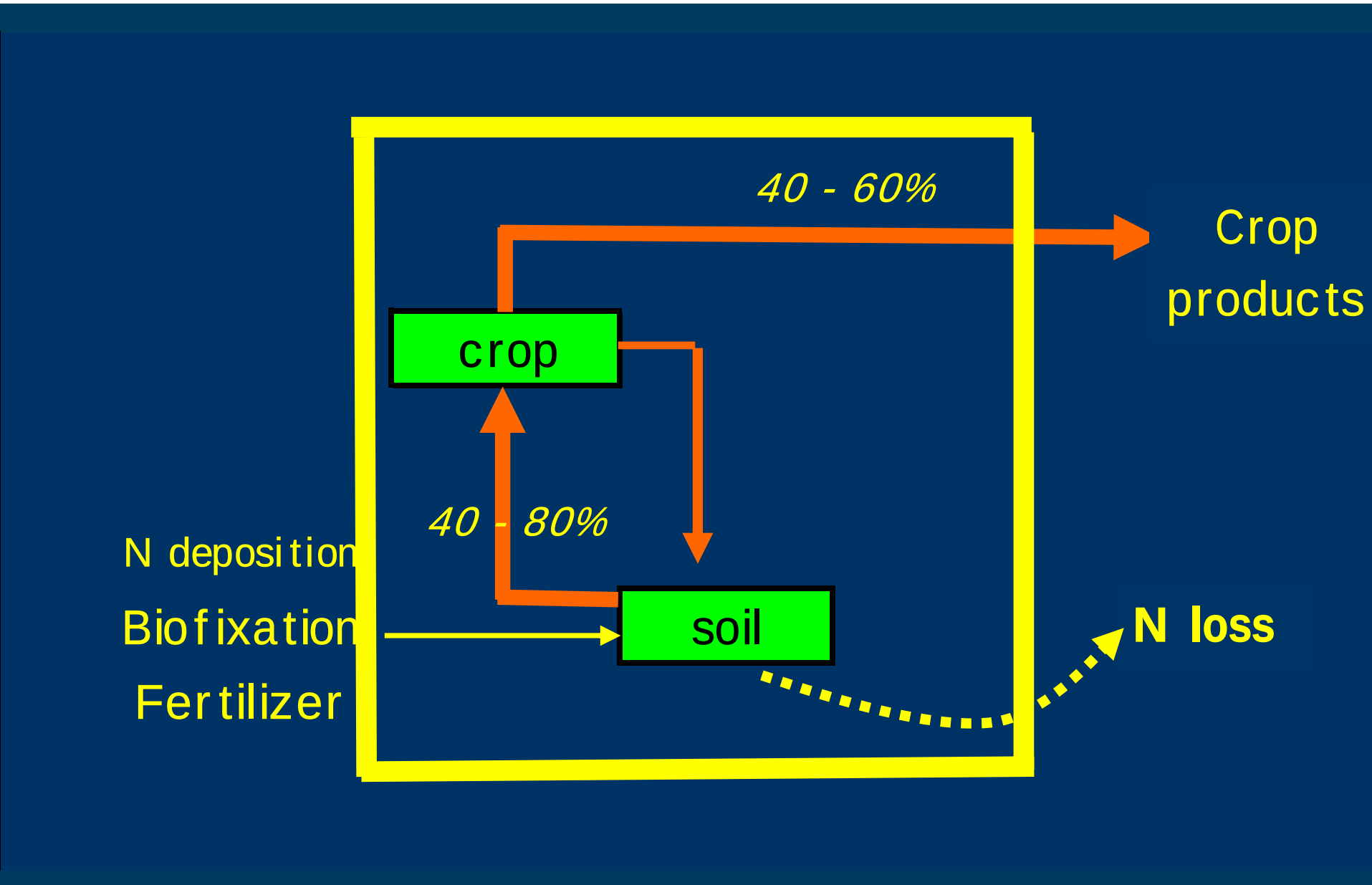
N budgets in Agriculture

In experiments, often

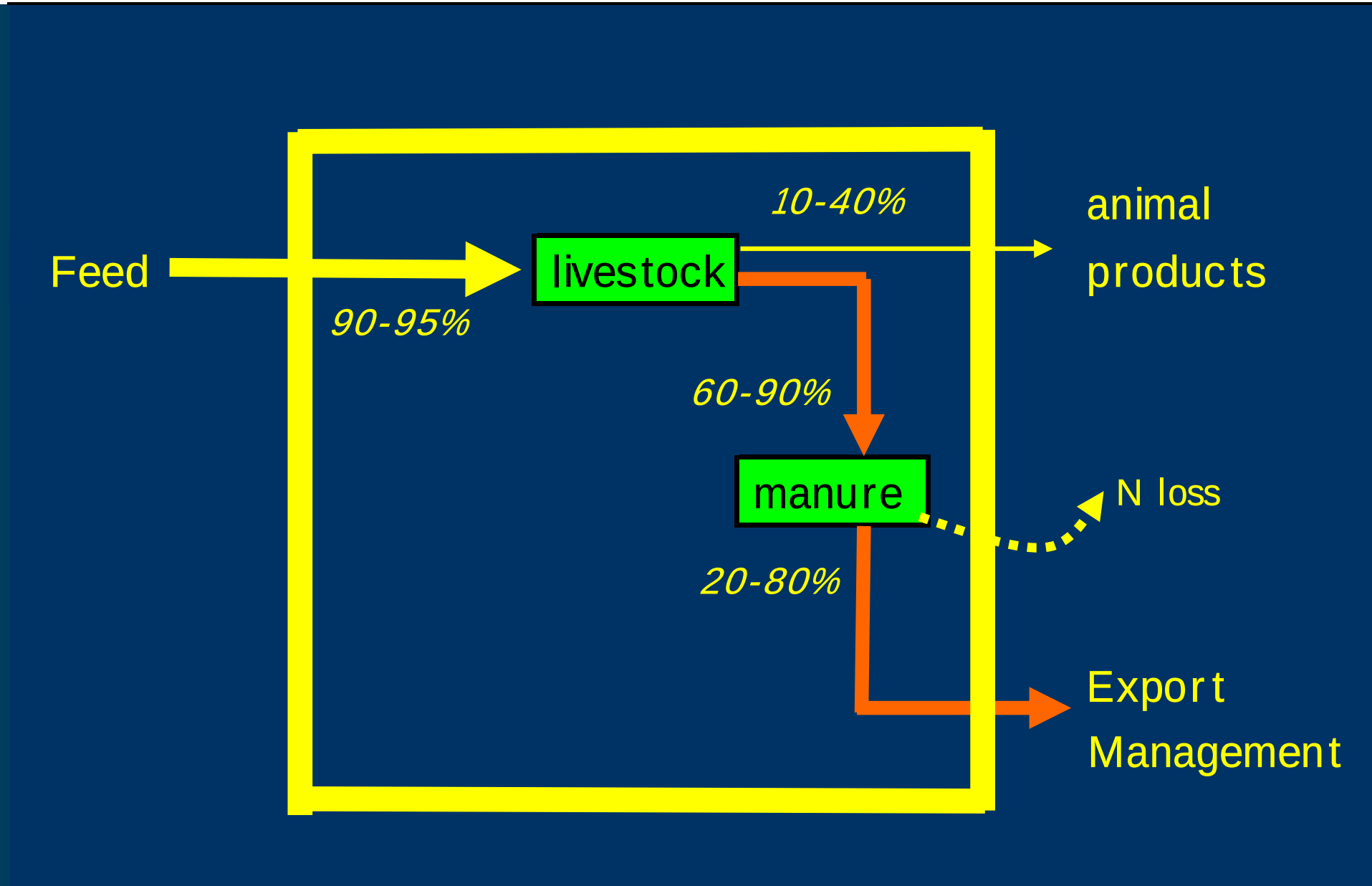
N inputs > N outputs + N losses

- *Allison (1955)*
  - *Enigma of the nitrogen balance*
- *Garrett et all (1993)*
  - *Unaccounted for N increases with N input in grazing systems*

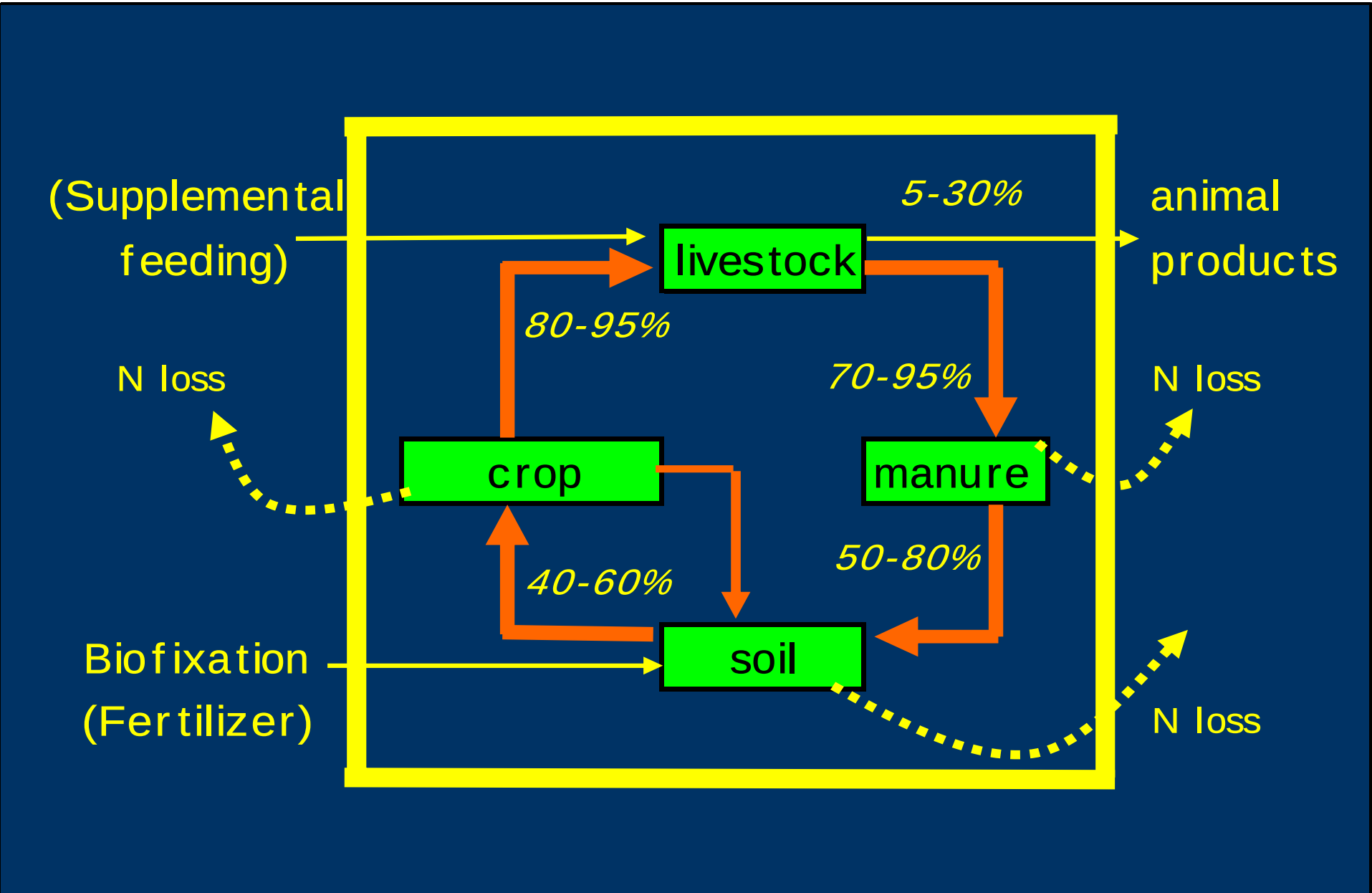
Nitrogen cycling in crop production



Nitrogen cycling in land-less animal farming

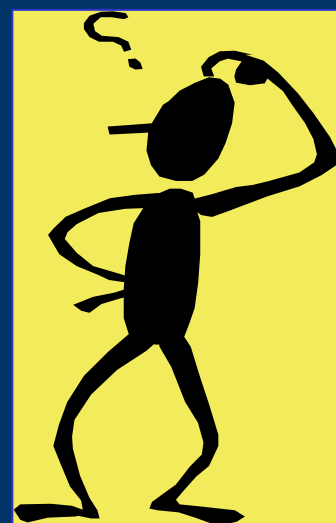


Nitrogen cycling in mixed systems



Nutrient budgets in Agriculture and confusion

- *Partial versus complete budgets*
- *Farm-gate versus soil surface budgets*
- *Compartment versus system budgets*
- *System A versus system B*
- *Static versus dynamic approaches*



N budgets beef & dairy systems, kg/ha/y

Budget item	Beef	Beef	Dairy	Dairy
Total Inputs	23	175	568	240
• Feed			182	80
• Fertilizer			330	74
• Deposition	15	14	49	49
• Biofixation	8	160		8
• Other			7	29
Total Outputs	13	60	561	200
• Milk			68	64
• Meat	3	23	10	13
• NH3 loss	3	10	129	32
• Denitrification	2	4	201	42
• Leaching	5	23	150	52
Balance	10	115	7	40
O/I efficiency,%	13	13	13	31

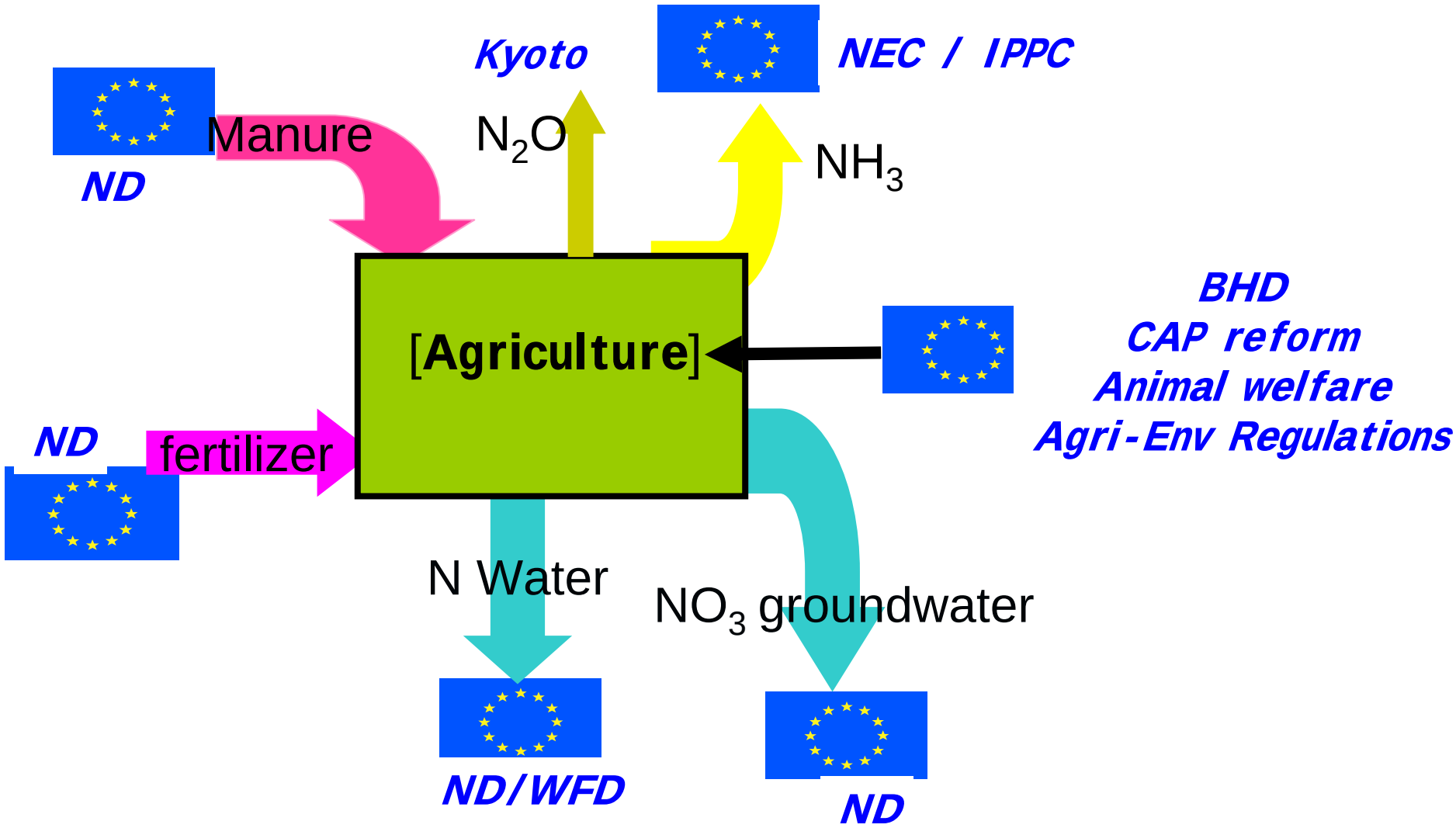
N budgets land-less farms, Mg/farm/yr

Budget item	Pig	Broilers	Layers
Total Inputs	20.8	21.8	36.8
• Feed	18.8	21.5	35.0
• Animals	2.0	0.3	1.0
• Other			0.8
Total Outputs	24.2	20.7	35.7
• Animals	9.4	10.6	1.9
• Eggs			11.1
• NH_3 loss	4.0	3.4	4.4
• Manure	10.7	5.8	18.1
• Other		0.9	0.3
Balance	-3.4	1.1	1.1
O/I efficiency,%	45	48	35

Inputs & Output/Input ratios (O/I)

	I (kg/ha)	O/I
• Crop production		
– Arable crops	10- 300	0.3-0.7
– Vegetables	100 -1000	0.2-0.6
– Glasshouses	500-2000	0.2-0.6
• Animal production		
– Grazing systems	10 - 100	0.1-0.2
– Mixed systems	100-500	0.1-0.3
– Land-less systems	10^3- 10^5	0.3-0.6

Agricultural N-flows and EU policies



Regulations hindering farm development

Regulations	Pig farmers, %	Poultry farmers,%
• Zoning restrictions	44	29
• Building permits	17	27
• Environmental permits	58	55
• Manure policy	26	30
• Production rights	34	35
• Nature conservation plans	10	12
• Animal health & welfare	21	38
• Food safety regulations	5	10
• Fiscal legislation	4	10

Source: Hartog et al., 2004

Categorizing of policies & measures

- Abatement of emissions of N species
  - Risks of pollution swapping
- Control of N input
  - Synergistic effects possible
- Spatial zoning
  - Complex; both, antagonistic and synergistic effects possible

Categorizing measures of Nitrates Directive

- Spatial zoning of Nitrate vulnerable zones
- Control of N input via animal manure (+ N fertilizer)
- Abatement of emissions of NO_3 leaching

Categorizing measures of CLRTAP / NEC / IPPC

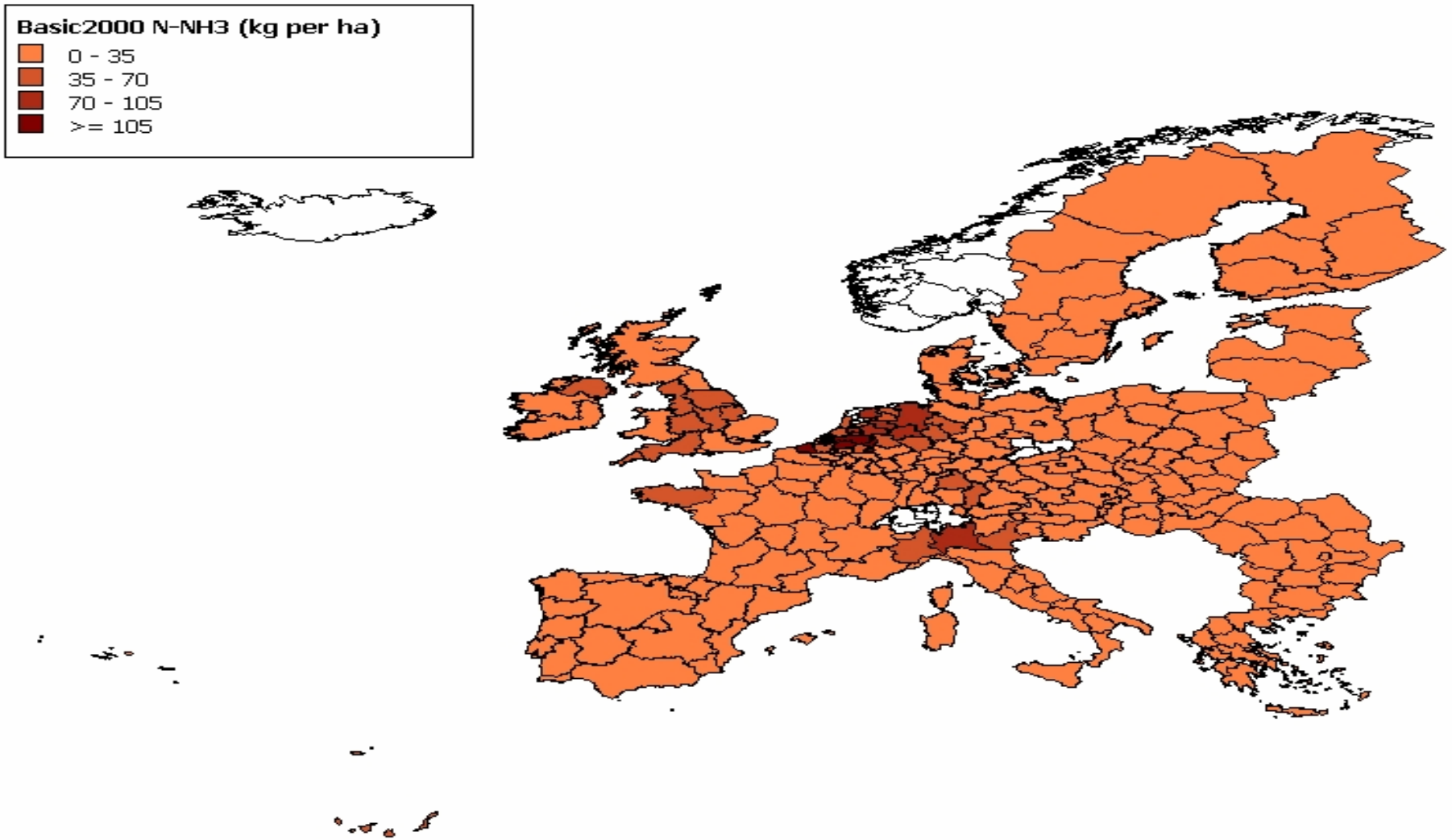
- Abatement of emissions of NH_3 (and other N species)
- Control of N input via animal feed
- Integrated approach and flexibility of IPPC may include spatial zoning

MITERRA-EUROPE

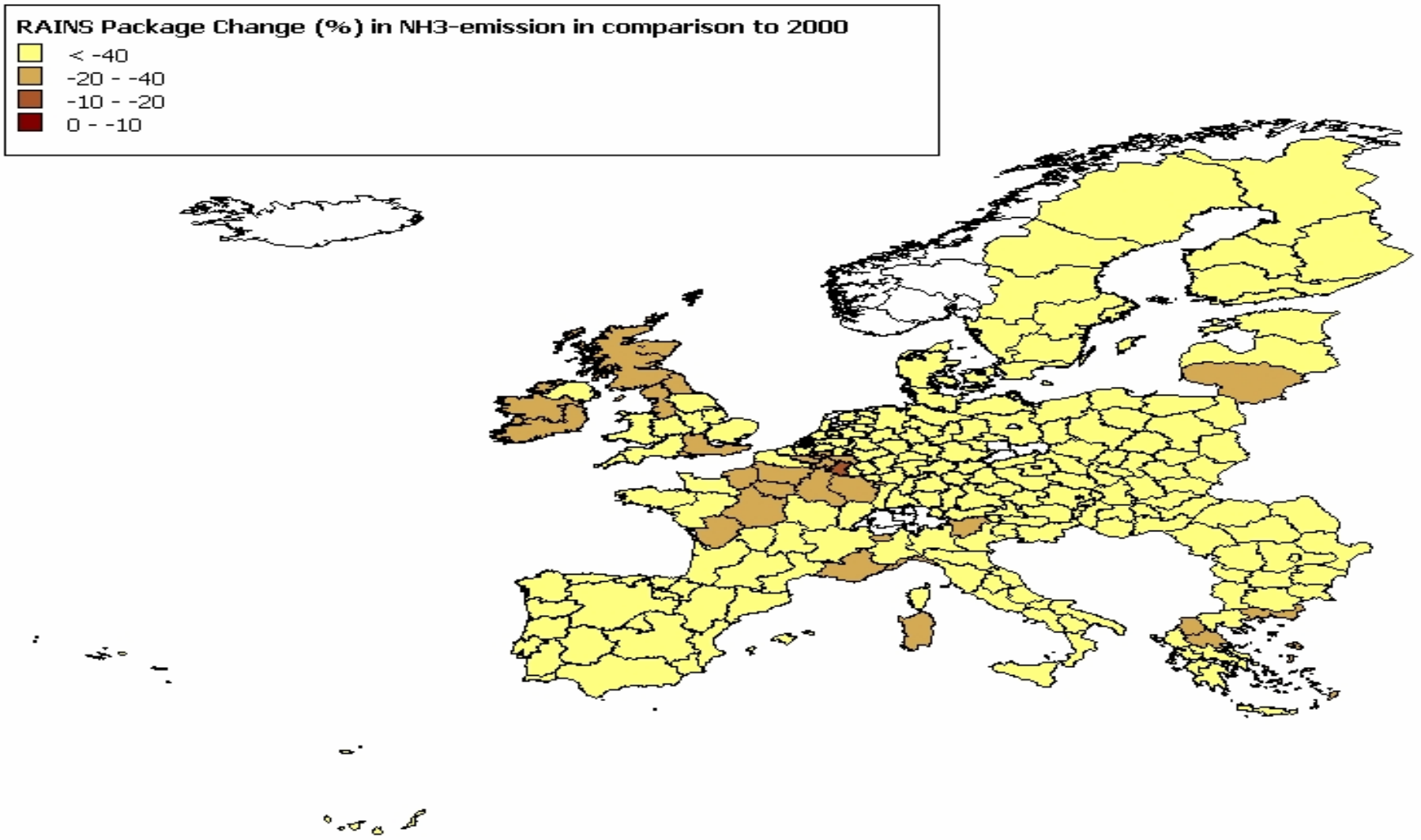
- Modelling tool to assess interactions between environmental policies in EU-25+:
  - Activity data: Eurostat and CAPRI
  - NH_3, N_2O and CH_4 emissions: following RAINS/GAINS
  - Nitrate leaching; newly developed, using Corine land use and JRC soil data

- Spatial scales
  - Country level
  - Nuts 2 level
  - Nitrate Vulnerable Zones

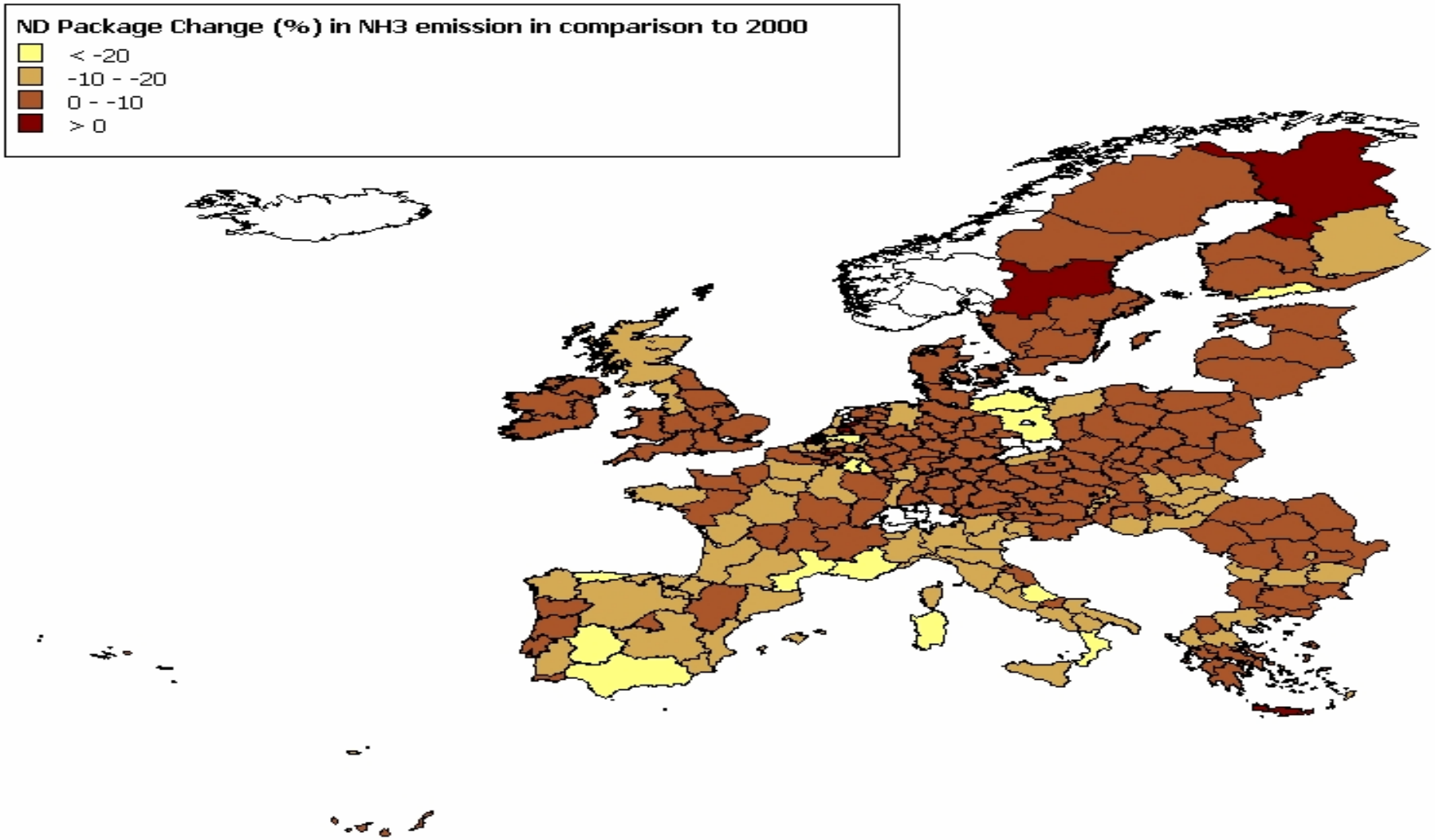
Ammonia emissions



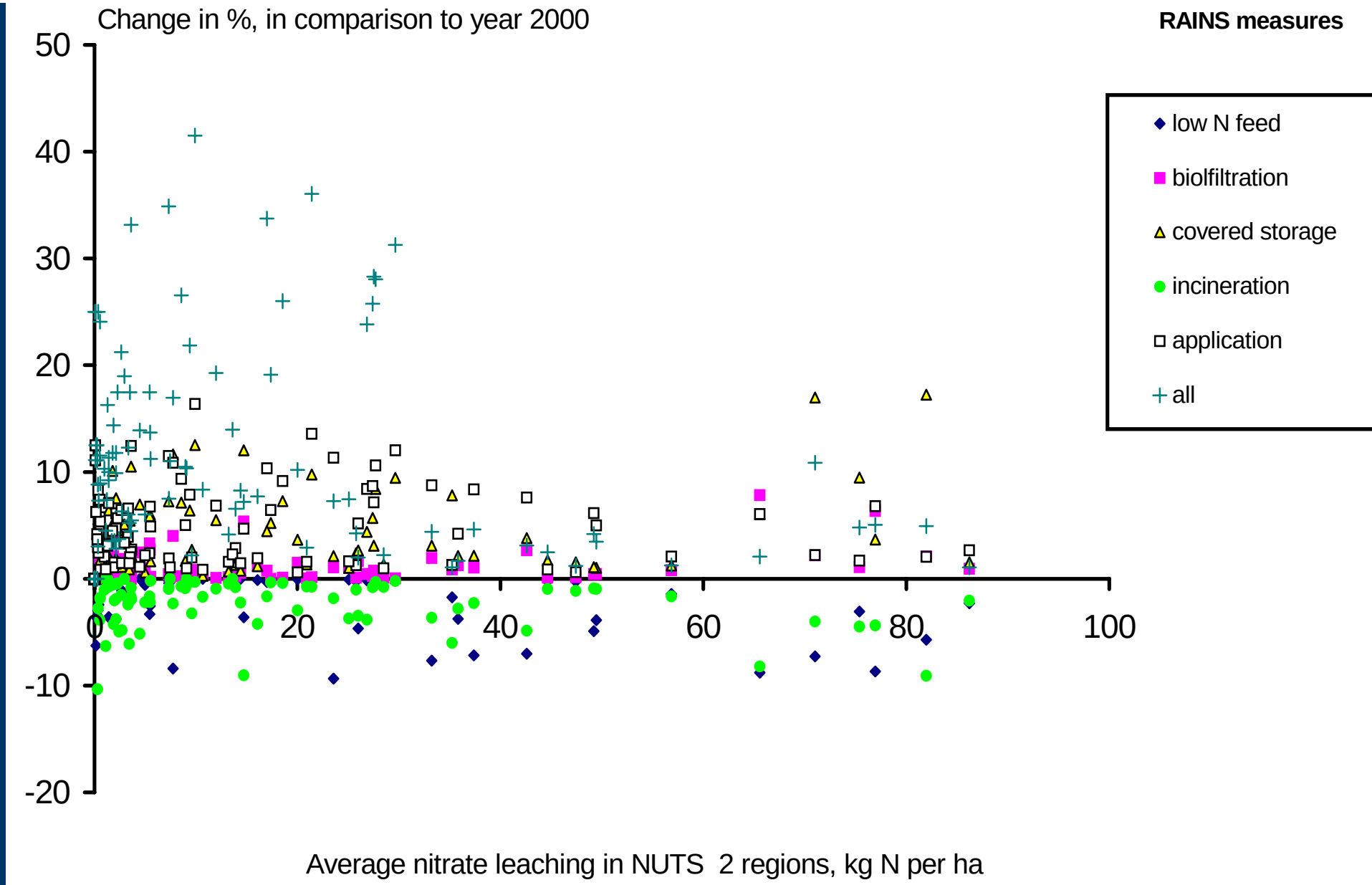
Effects of 'RAINS' measures on NH_3 emissions



Effects of 'ND' measures on NH_3 emissions



Effects of 'RAINS' measures on NO_3 leaching



Mean effect of RAINS and ND measures, %

Measure		NH_3 EU-25	NO_3 EU-15	N_2O EU-25
Ammonia	Biofiltration	-6	1	0
	Low ammonia application - high	-11	4	8
	Covered storage - high	-4	4	0
	Stable adaptation	-23	8	5
	Low nitrogen feed	-3	-2	-1
	Incineration	-4	-3	-1
	Urea substitution	-8	2	-1
	Package	***-49***	***11***	***7***
Nitrate	Balanced fertilization	-10	-63	-22
	Maximum manure application	0	0	0
	Limit on slopes	-2	-4	-2
	Optimal storage	0	1	0
	Application techniques	0	-10	0
	No winter application	-1	-10	-3
	Winter crops	0	-5	0
	Package	***-10***	***-65***	***-23***

Conclusions

- Synergistic effects of abatement measures emerge from N input control
- Pollution swapping emerges from abatement of N emissions *without* N input control
- Measures of CLRTAP / IPPC increase NO_3 leaching more than ND measures increase NH_3 emissions