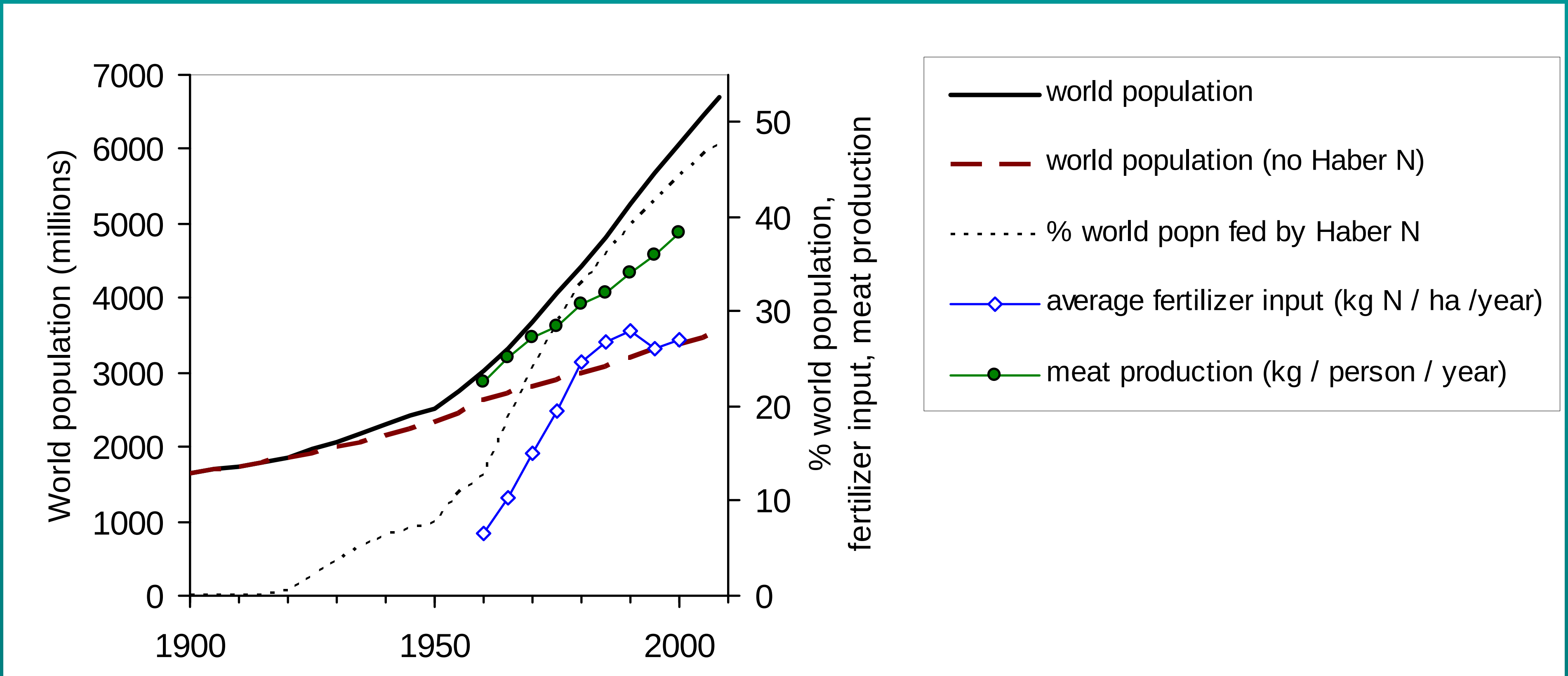
True Cost Accounting and the nitrogen cycle

Mark Sutton
CEH Edinburgh

Workshop at University of Edinburgh
4 June 2014

UNEP

Ammonia feeds the world

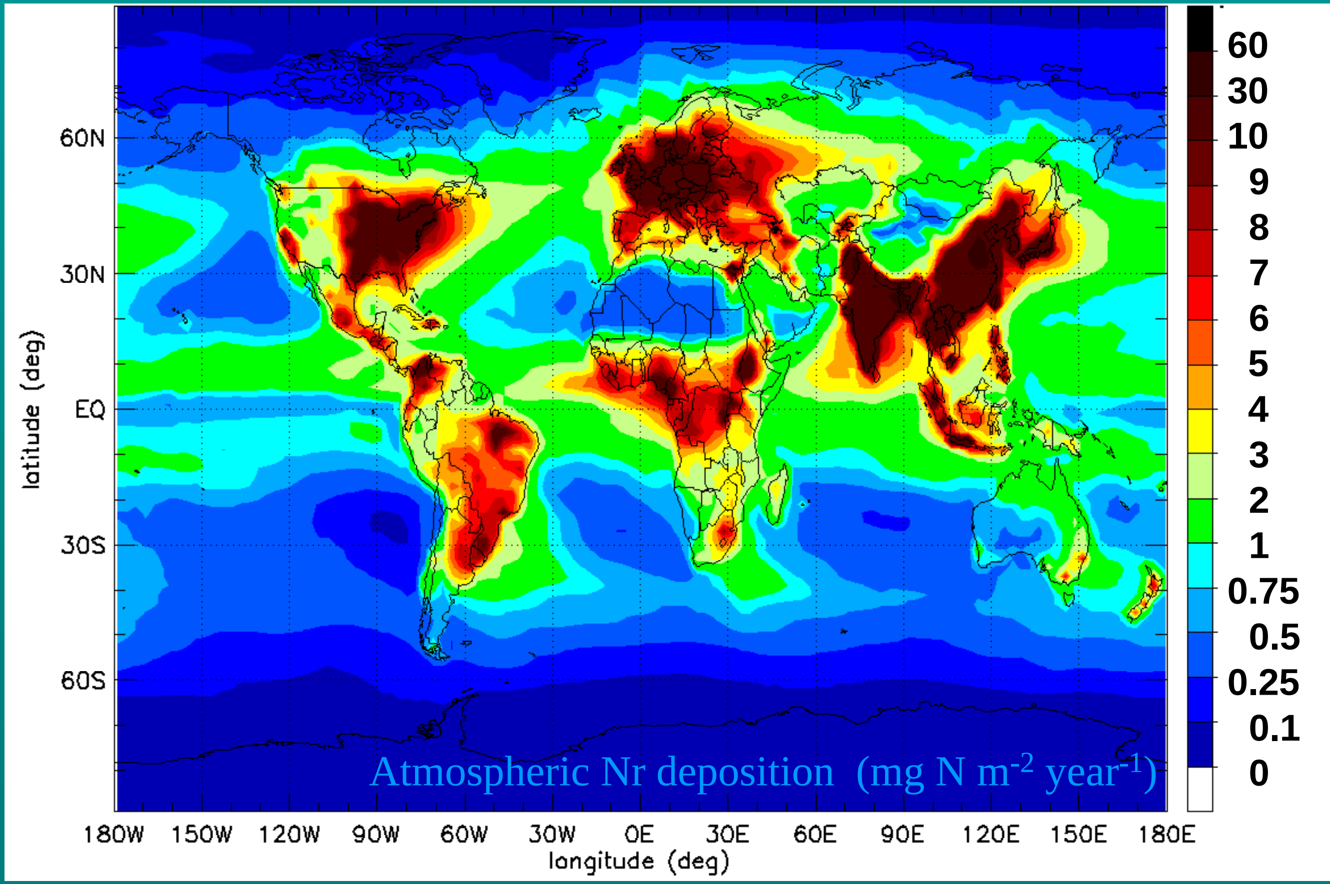


Erisman, Sutton, Galloway, Klimont & Winiwarter
Nature Geoscience 2008

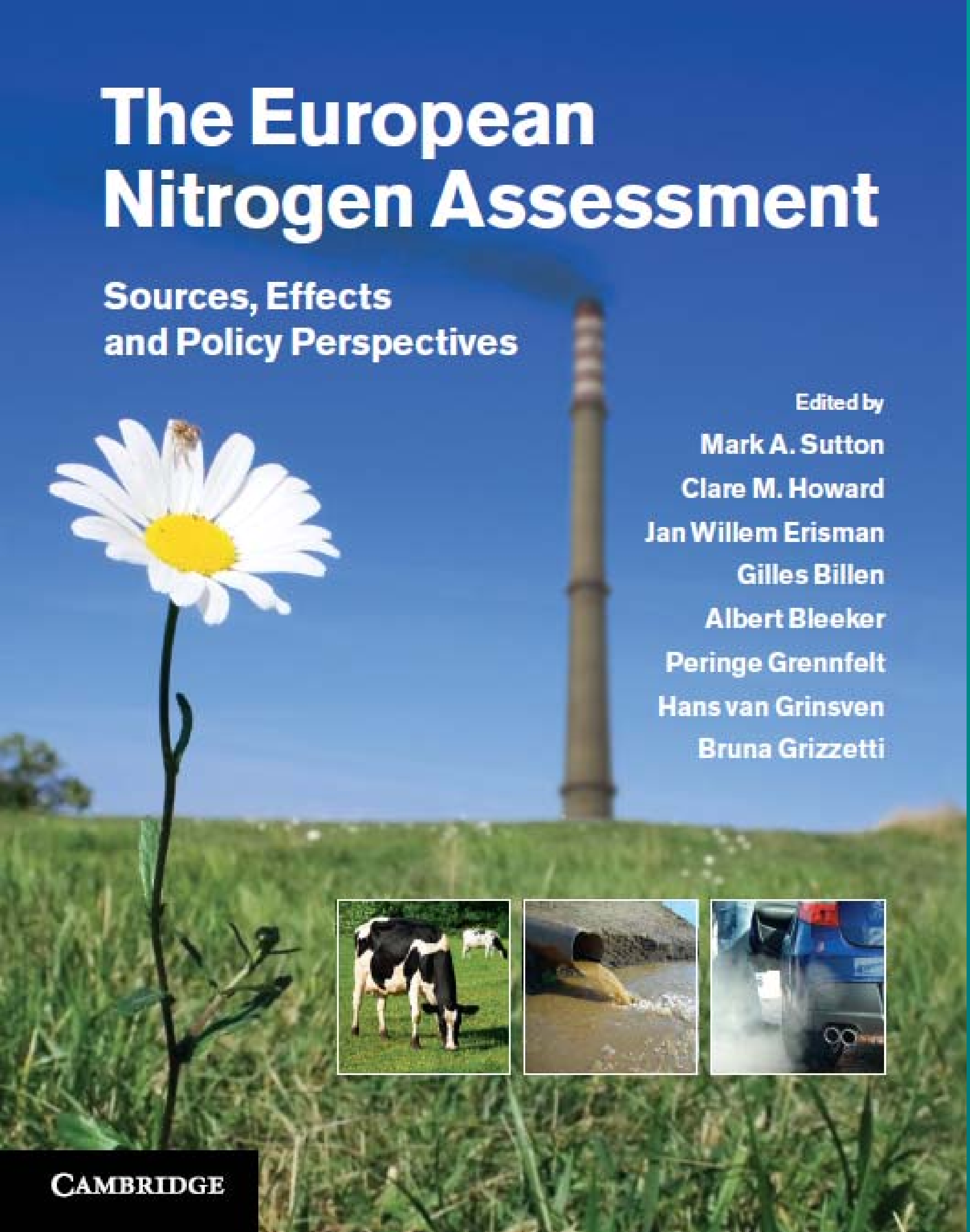
Global N production & dispersion

Human Nr Production:
(Tg yr^{-1})
1860: 15
1995: 156
2005: 191

2005 sources:
Haber Bosch: 121
Biol N fixn: 45
NOx emission: 25



Galloway et al. *Science* (15 May 2008)



ENA Launch

11-15 April 2011
Edinburgh
International Conference
"Nitrogen & Global Change"

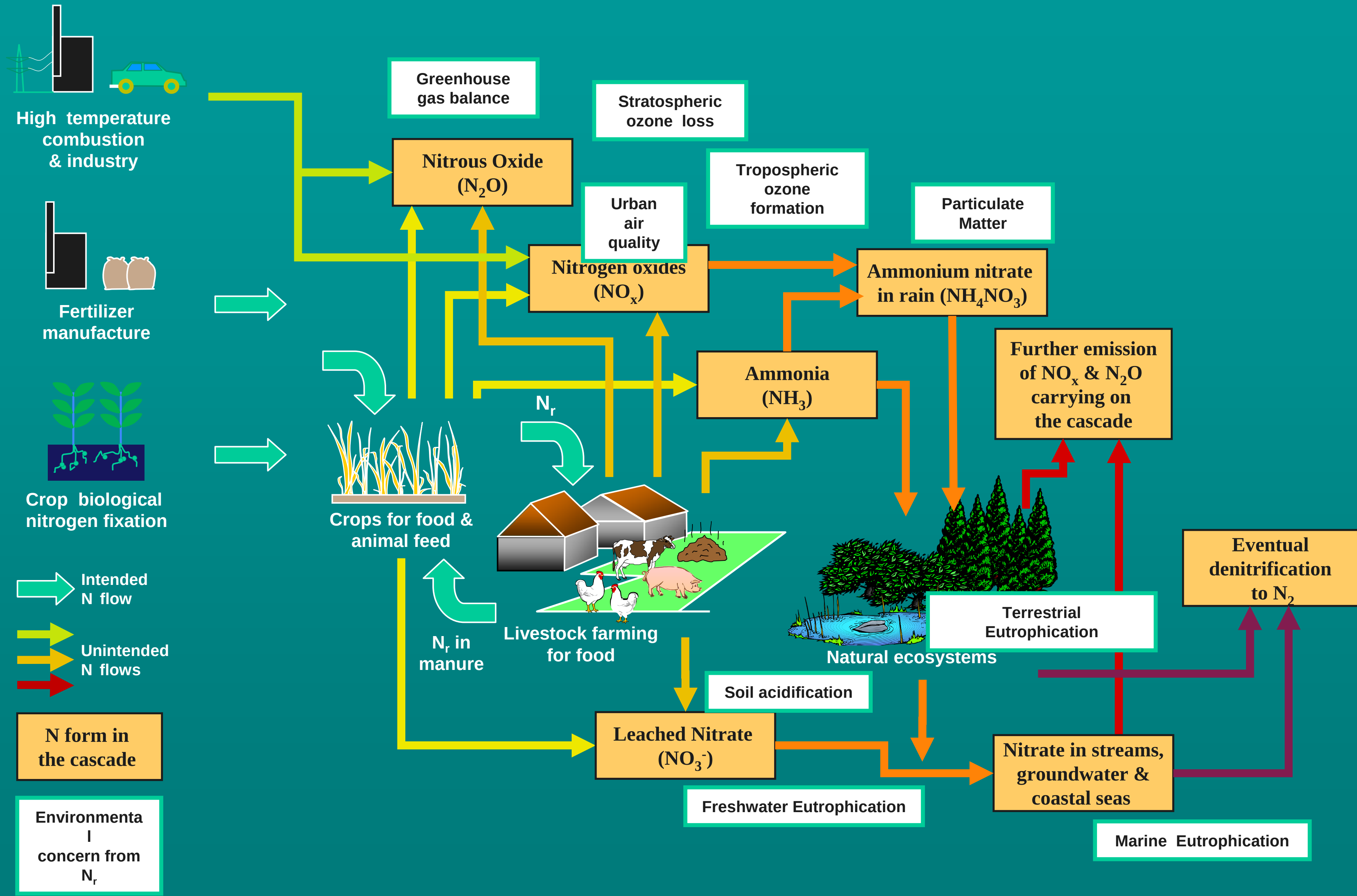
ENA Authorship

200 experts,
21 countries &
89 organizations

Scientifically independent process

www.nine-esf.org/ENA

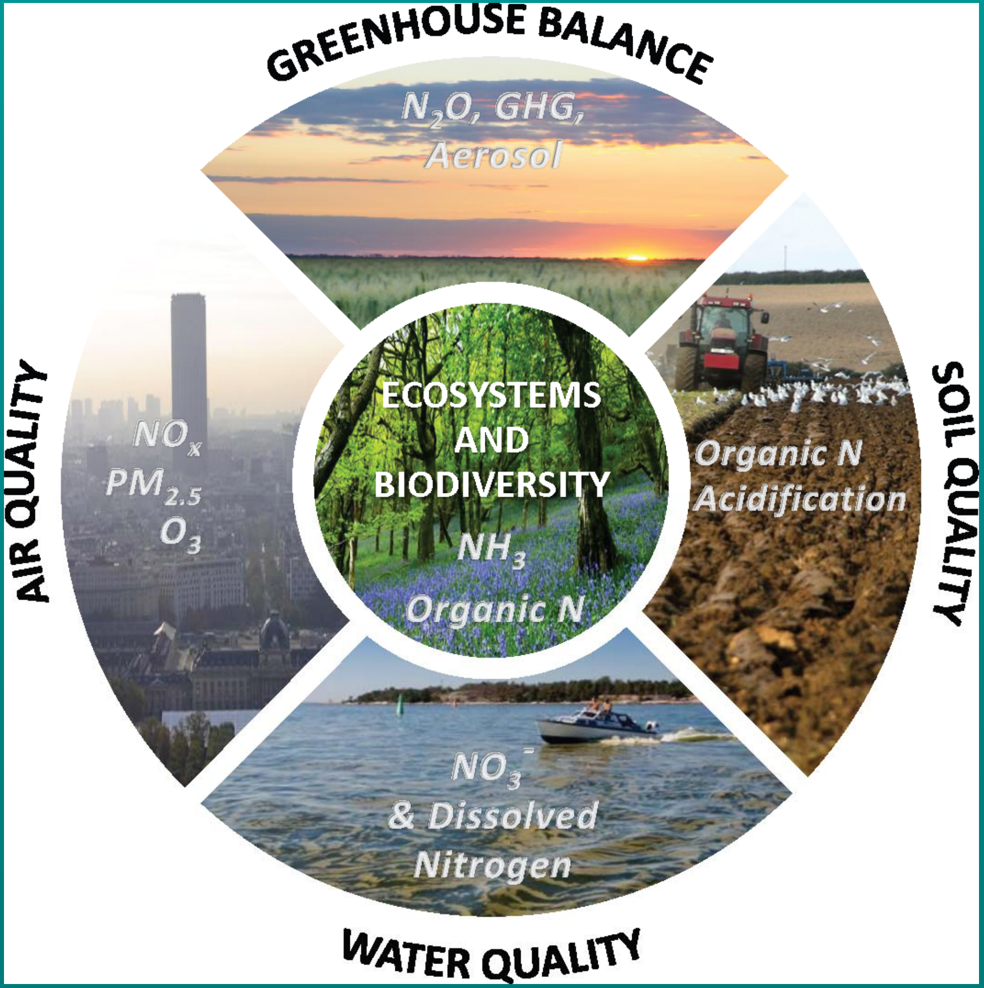
Simplified view of the Nitrogen Cascade



The five key threats of excess Nitrogen

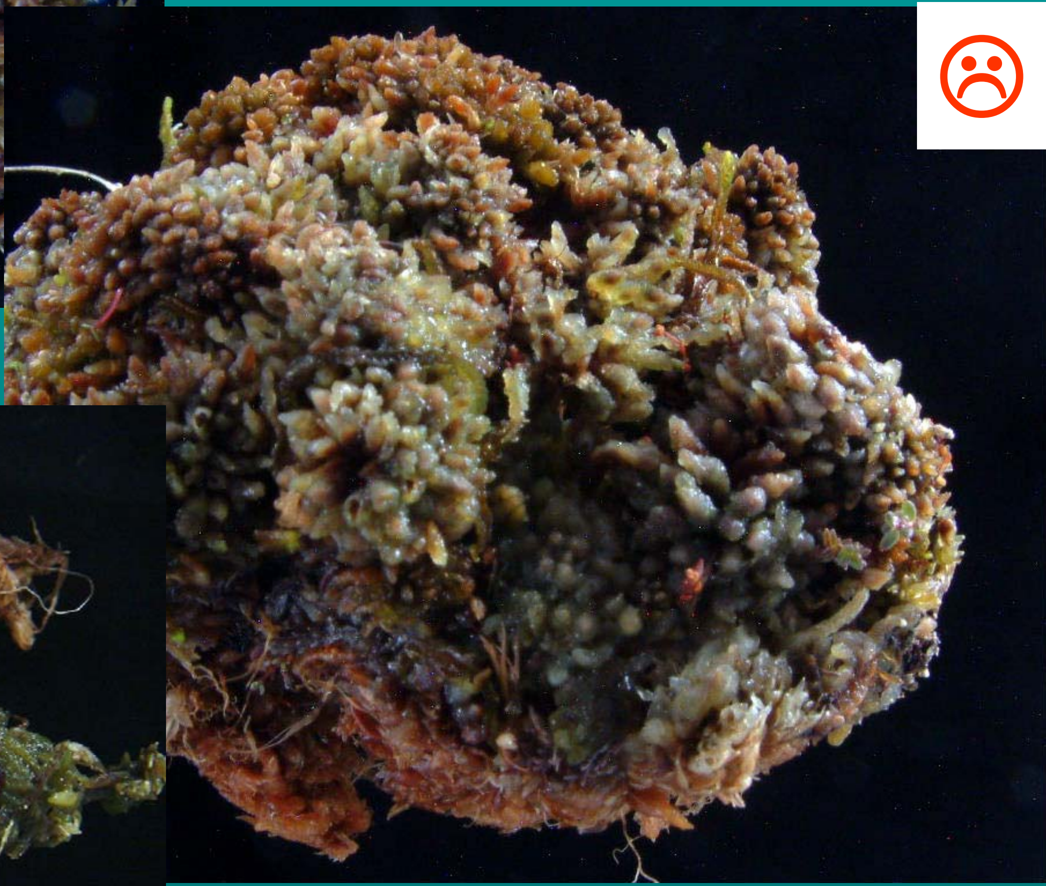
The WAGES of too much nitrogen

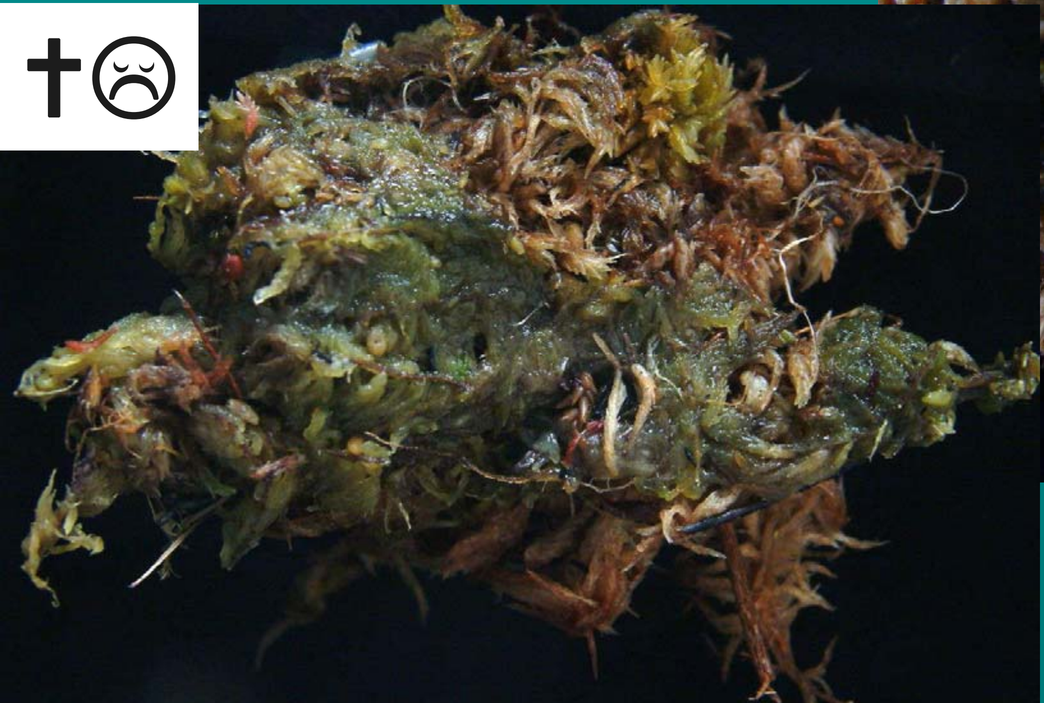
Water quality
Air quality
Greenhouse balance
Ecosystems
Soil quality



Lichen: Cladonia uncialis

Bog moss
Sphagnum imbricatum





Total NO_x emissions [kg N km^{-2}yr^{-1}]

Split of total NO_x emissions for EU27 [Gg N year^{-1}]

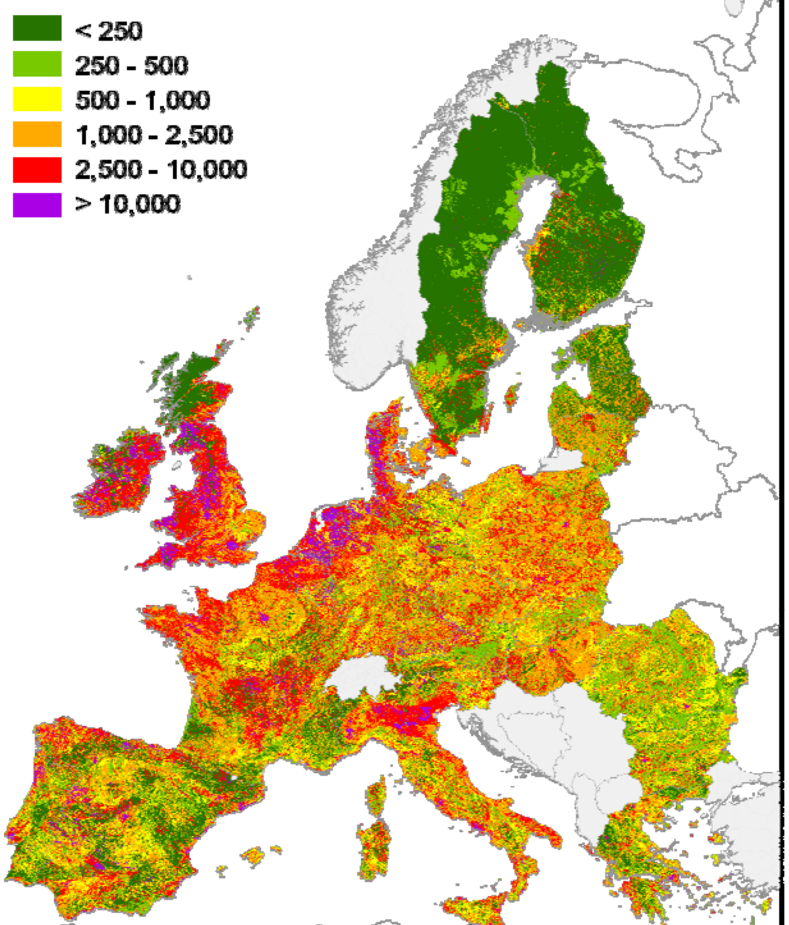
Total NH_3 emissions [kg N km^{-2}year^{-1}]

Split of total NH_3 emissions for EU27 [Gg N year^{-1}]

Total N_2O emissions [kg N km^{-2}year^{-1}]

Split of total N_2O emissions for EU27 [Gg N year^{-1}]

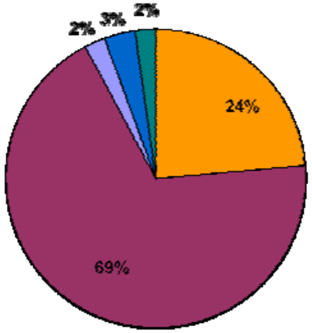
N-input to acquatic systems [kg N km^{-2}yr^{-1}]



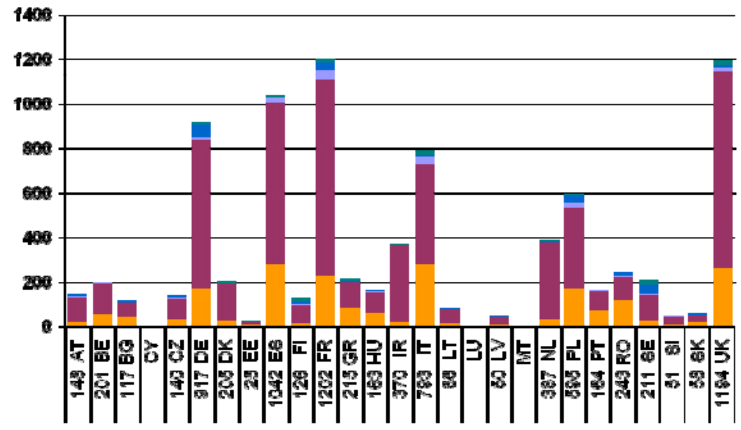
Projection: LAEA (Central Meridian: 10, Latitude of Origin: 52); Resolution: 1km².
Legal Notice: Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of this publication.
IDEAg VI, INTEGRATOR and EMEP MSC-W model rv3_3

Split of N-input to acquatic systems for EU27 [Gg N year^{-1}]

Direct sewage	2050
Diffuse agric. soils	5980
Diffuse agric. livestock	200
Diffuse - forests	290
N-deposition	190
Total	8710

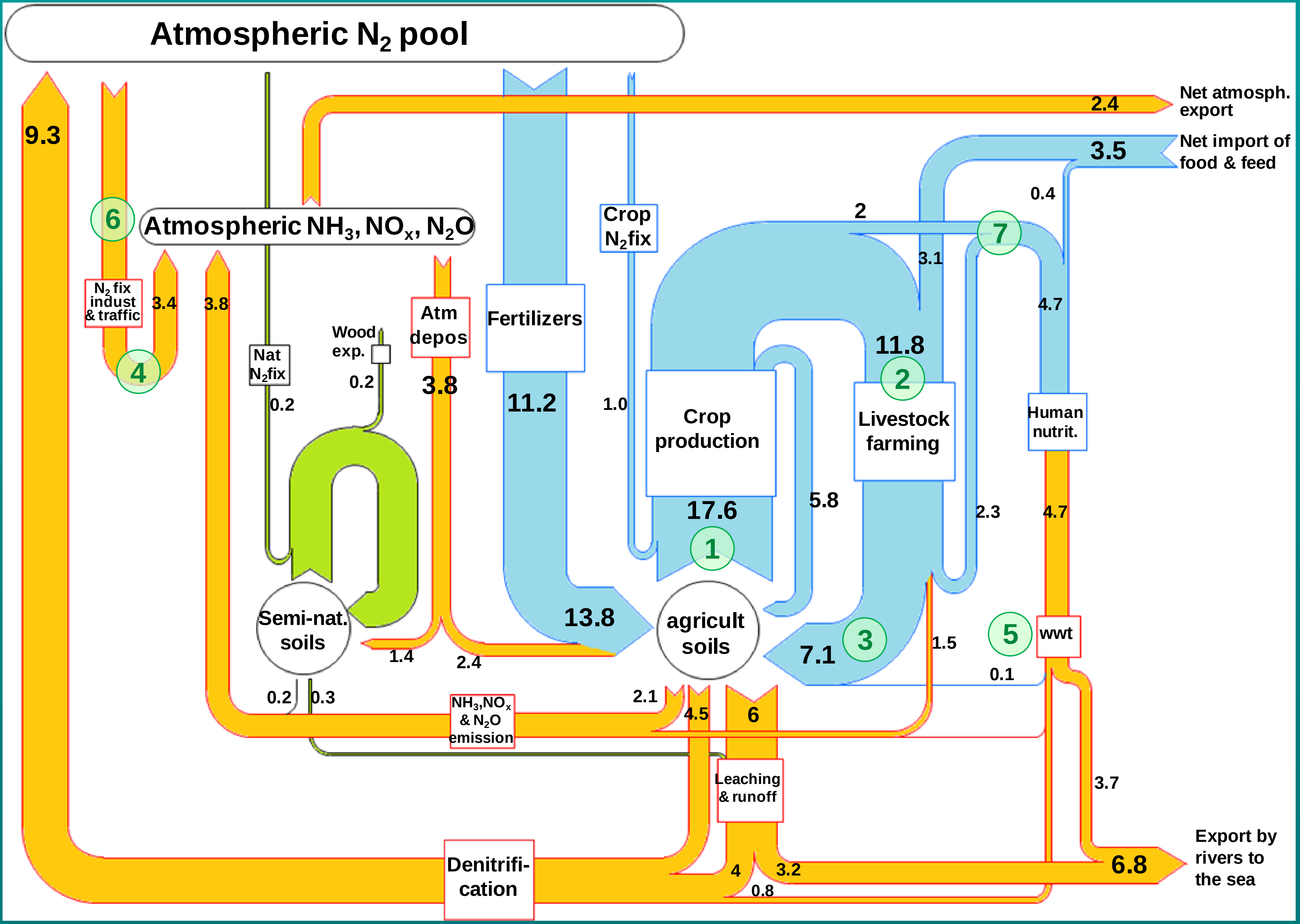


Split of N-input to acquatic systems by country [Gg N year^{-1}]



AL/HR, 27.07.2010, ©European Communities, 2010

Summary of N flows in Europe



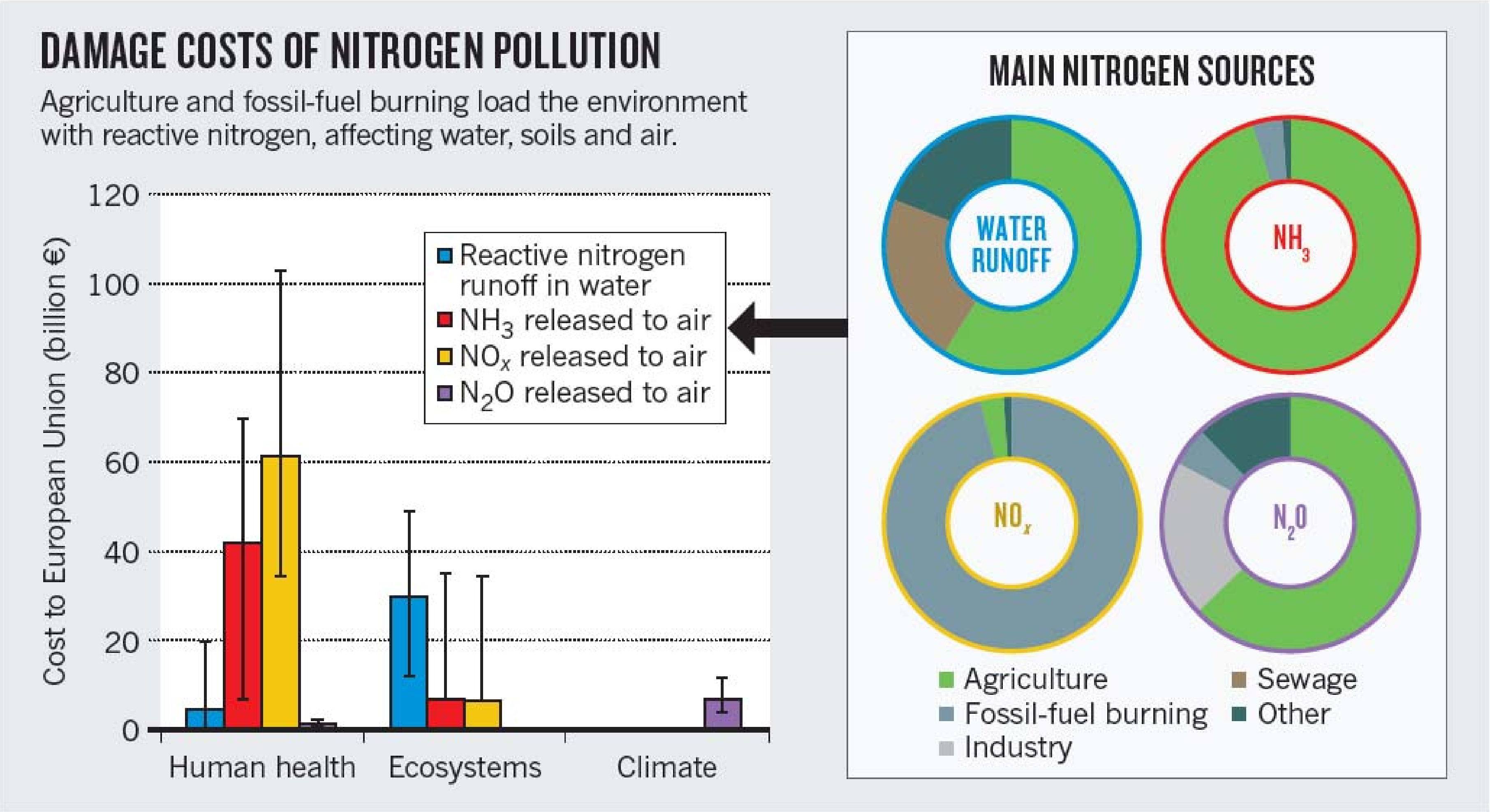
ENA: Comparison of Organic and Conventional Farming

Table 10.1 Summary of annual N in products and losses (kg/ha) derived from the typical farm nitrogen budgets (Figures 10.11–10.15), with losses also expressed per unit N in products

Farm management	Nitrogen in crop and animal products	Nitrogen losses		N losses per unit N in products (as ratio)
	kg/ha/year N			
Arable	99	84		0.85
Pig	159	131		0.82
Beef	40	108		2.7
Dairy (conventional)	56	143	**200**	2.55
Dairy (organic)	39	75	**90**	1.92

Jarvis et al. (2011) European Nitrogen Assesment

Nitrogen Damage Costs & Sources



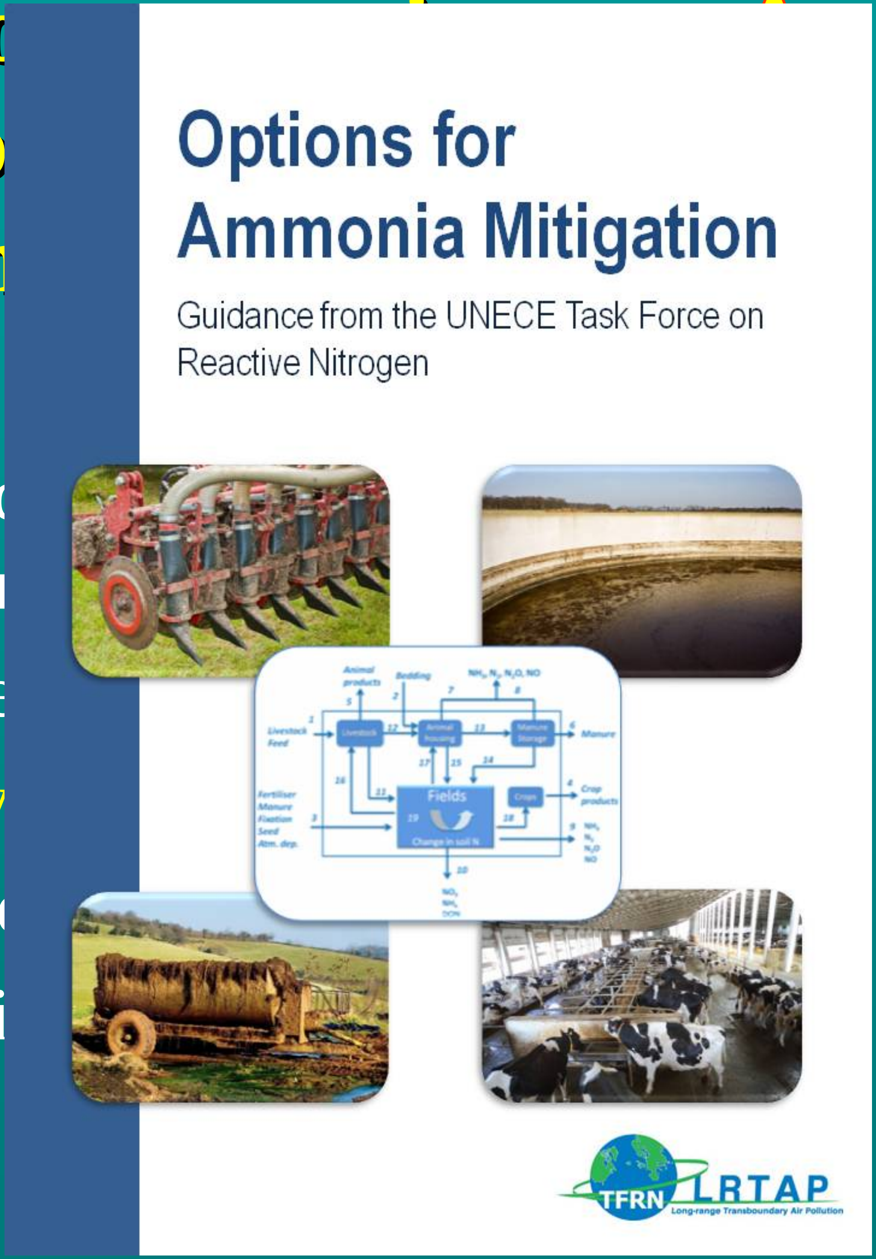
EU Damage cost: 70 - 320 billion € / year

Nature 14 April 2011

5 priorities fo
in revisio
UNECE Gothen

(1=highest priority)

1. Low emission techni cattle/pig/poultry ma
2. Animal feeding strate
3. Covers on new slurry
4. Farm N balance on d
5. Low emission new pi



Slurry spreading:

a wide range of low-emission techniques are available


Splash Plate Spreader
- 1950s technology

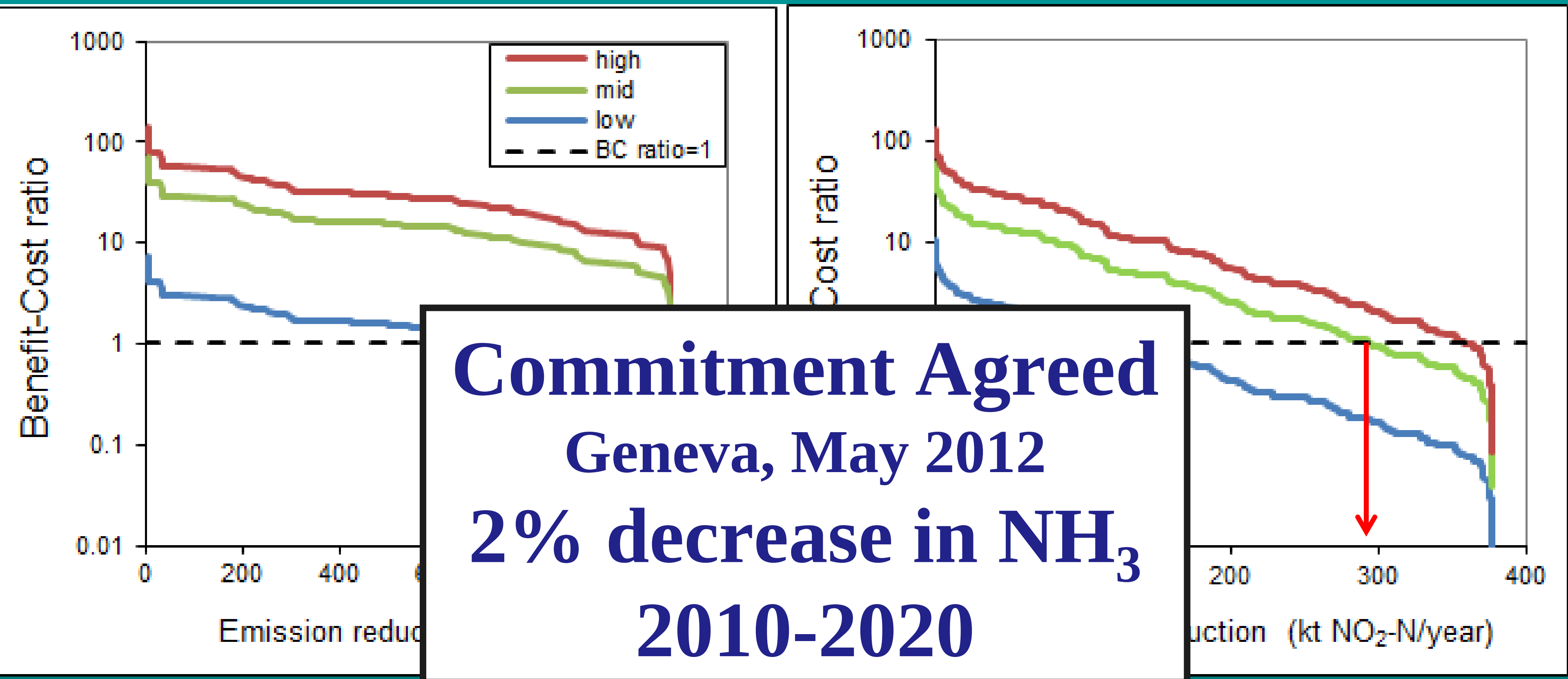

Trailing Hose


Trailing Shoe


Slot Injector

The car and the exhaust pipe…

EU benefit-cost ratios for NH_3 and NO_x mitigation



Commitment Agreed

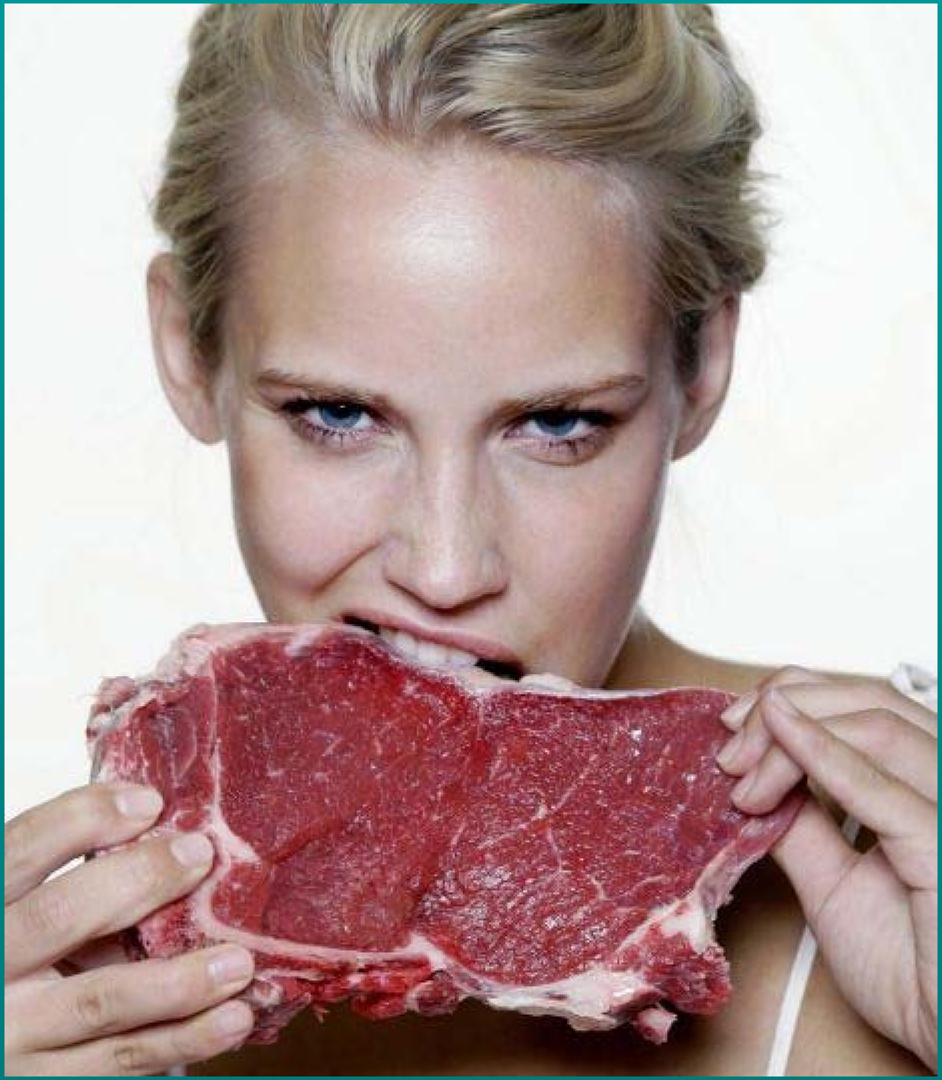
Geneva, May 2012

2% decrease in NH_3

2010-2020

Van Grinsven et al. (*Environmental Science and Technology*, 2013)

LRTAP Long-range Transboundary Air Pollution



Metro 10 April 2011

"£650-a-year nitrogen pollution could be reduced by eating less meat"

Press Comment on the *European Nitrogen Assessment*

Nitrogen: Food security or food luxury?

- Often said: "*We need N for food security*"
- European Nitrogen Assessment (2011)
  - 85% of N in EU harvests goes to feed livestock
  - The average European eats 70% more protein than needed for a healthy diet
  - Europe is a net *importer* of N in feed & food
- The reality is *Food Luxurity*
  - Society wants "the security of food luxury"
  - The key challenge to optimize (reduce) meat consumption to improve our quality of life

Nitrogen and a Demitarian Europe?

Example scenario of 50% consumption reduction

Aspect	Unit	Reference	-50% meat, dairy and eggs
Protein			
Average daily intake	g cap^{-1} day^{-1}	83	75
Proportion of animal origin	%	60%	36%
Red meat			
Average daily intake	g cap^{-1} day^{-1}	88	47
Compared with the RMDI	%	207%	107%

Westhoek and the TFRN-EPNF (*Global Environmental Change*)

LRTAP

Long-range Transboundary Air Pollution

UNEP

TFRN goes global

UN says fertiliser crisis is damaging the planet

Scientists urge rich world to halve its meat consumption

The shape of nitrogen to come

An analysis reveals the huge impact of human activity on the nitrogen cycle in China. With global use of Earth's resources rising per head, the findings call for a re-evaluation of the consumption patterns of developed societies.

MARK A. SUTTON & ALBERT BLEEKER

Although Earth's atmosphere consists of nearly 80% dinitrogen (nitrogen

NO_x to the formation of ground-level ozone, which causes crop losses; increased emissions of nitrous oxide (N_2O), a greenhouse gas; and extreme levels of water pollution by nitrates

Nature doi:10.1038/nature11954

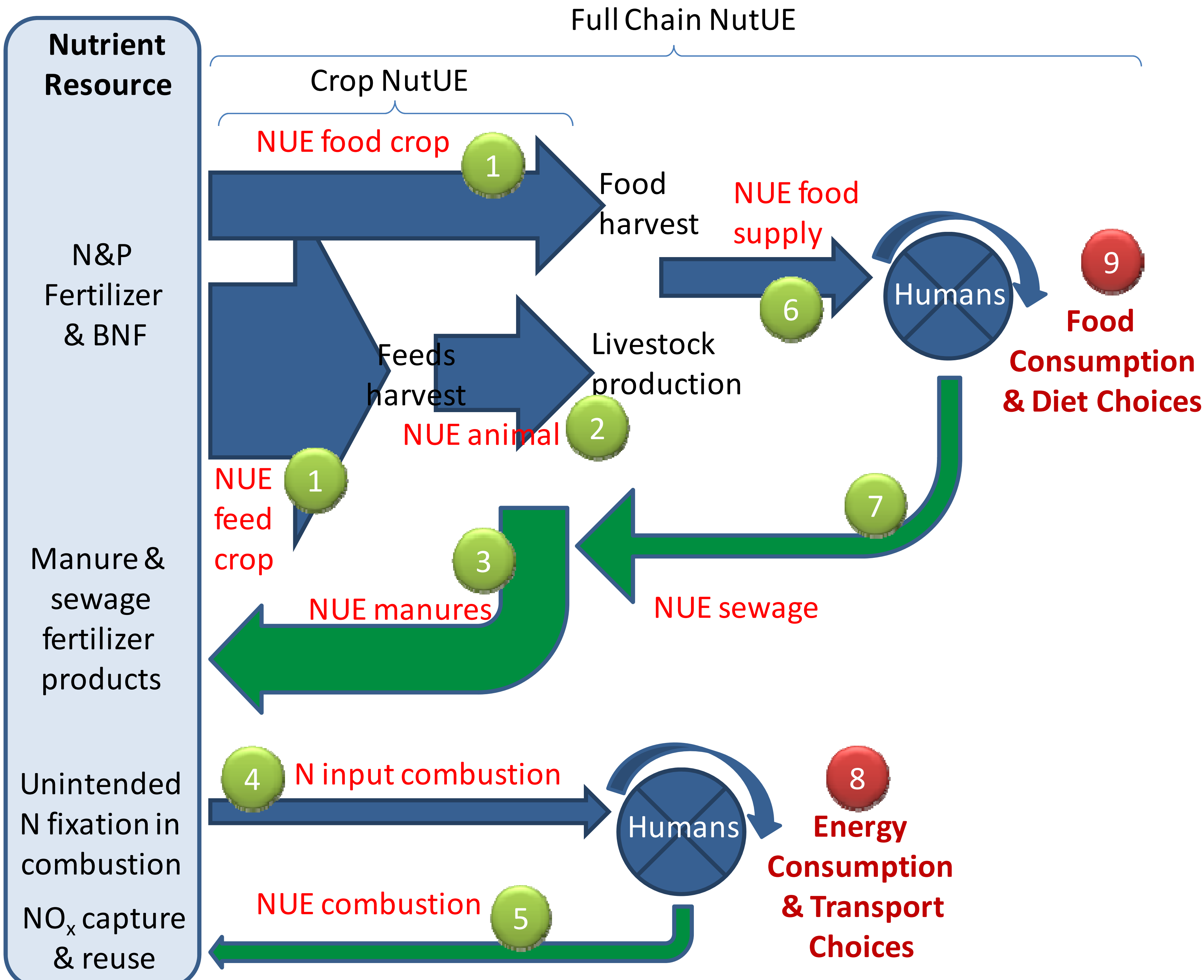
18 Feb 2013: *Independent , Guardian, Herald Tribune, Times of India* and 300 articles worldwide

Global Overview on Nutrient Management

Our Nutrient World

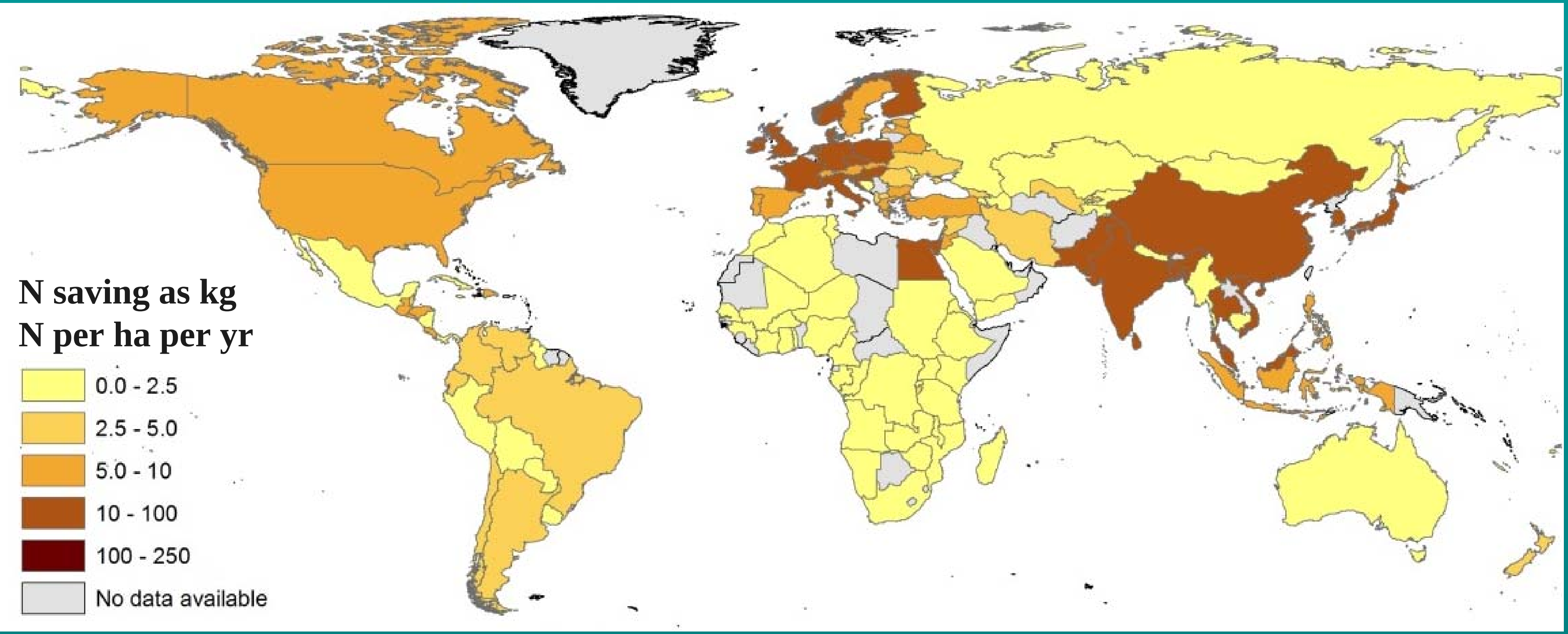
The challenge to produce more food and energy with less pollution

Prepared by the Global Partnership on Nutrient Management in collaboration with the International Nitrogen Initiative


Full Chain NutUE
Crop NutUE
Nutrient Resource
N&P Fertilizer & BNF
Manure & sewage fertilizer products
Unintended N fixation in combustion
NO_x capture & reuse
NUE food crop
1
Food harvest
NUE food supply
6
Humans
9
Food Consumption & Diet Choices
Feeds harvest
Livestock production
NUE animal
2
NUE feed crop
1
7
3
NUE manures
NUE sewage
4
N input combustion
Humans
8
Energy Consumption & Transport Choices
NUE combustion
5

"20:20 for 2020"

20% better NUE: saving 20 Mt N per yr by 2020



Benefits expressed here as equivalent N saving / ha per year from the Full-chain NutUE target

Bottom line for the Green Nutrient Economy (£billion/year)

Net Benefit 110= Fert Saving 15 + Env+Health 102 –Implementation 8

Where to next?
UN Global Environment Facility

- Global nitrogen cycle, toward *International Nitrogen Management System (INMS)*
- **Opportunities**
  - Sharing CLRTAP experience within GPA – linking intergovernmental processes.
  - Improving indicator development, moving to operational delivery
  - Sharing and development of mitigation and management practices – understanding barriers
  - Case studies supported, including EECCA (e.g. East Baltic, Black Sea, Central Asia).