ESF conference in partnership with LFUI

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ESF Research Conferences

A Programme of the European Science Foundation

ESF-FWF Conference in Partnership with LFUI

Reduced Nitrogen in Ecology and the Environment

Universitätszentrum Obergurgl • Austria • 13-18 October 2006

Chair: Jan W. Erisman • Energy Research Center of the Netherlands (ECN), NL

Co-Chair: Mark Sutton • Centre for Ecology & Hydrology, Edinburgh, UK

Invited Speakers will include

R. Bobbink Utrecht U., NL • **S. Castaldi** Napoli U., IT • **D. Fowler** CEH, Edinburgh, UK
P. Grennfelt IVL Svenska Miljöinstitutet, SE • **P. Liss** East Anglia U., UK • **D. Möller** TU Cottbus, DE
O. Oenema Wageningen U., NL • **B. Pyatt** Nottingham Trent U., UK • **J. Raven** Dundee U., UK
H. Rennenberg Freiburg U., DE • **N. Risgaard-Petersen** NERI., DK
J. Roelofs Radboud U., Nijmegen, NL • **J.K. Schjørring** Inst. for Jordbrugsvidenskab, Frederiksberg, DK
M. Sutton Centre for Ecology & Hydrology, Edinburgh, UK

Objectives and aims

- ‘A conference at the forefront of scientific developments in an area where scientific interdisciplinary progress is needed’
- Aim for a set of papers for a peer reviewed journal to provide the state of knowledge, gaps and ways to make progress.
- Plenary presentations, discussions, posters and informal exchange of ideas both inside and outside the lecture room will be encourage to reach the targets.

Conference issues

- Program:
- Posters
- Papers: Environmental Pollution (150)
- Deadline: December 15 (electronic system)
- Guest editors: Mark Sutton, Peringe Grennfelt and me
- Availability of presentations

Saturday 14 October	16.00 onwards	Registration at ESF-RC desk	
	20.00	Dinner	
	21.00	Welcome Drink	
Sunday 15 October	08.45-09.00	Conference Opening	
	Session 1 • Atmosphere – biosphere interactions Chair: Jan Willem Erisman • Energy research Centre of the Netherlands, Petten, NL		
	09.00-09.35	Jan Willem Erisman • Energy research Centre of the Netherlands, Petten, NL	*Reduced Nitrogen in Ecology and the Environment*
	09.35-10.10	Mark Sutton • Centre for Ecology & Hydrology, Penicuik, Edinburgh, UK	*An historical perspective on ammonia*
	10.10-10.45	Ineke Stulen • University of Groningen, Haren, NL	*The role of ammonia in plant physiology*
	10.45-11.10	Coffee break	
	Short oral presentations		
	11.10-11.35	Johan Neirynck • Research Institute for Nature and Forest, Geraardsbergen, BE	*Bidirectional ammonia exchange above a mixed coniferous forest*
	11.35-12.00	Eiko Nemitz • Centre for Ecology & Hydrology, Penicuik - Edinburgh, UK	*Ammonia - ammonium interactions: effects on surface/atmosphere exchange fluxes and the atmospheric aerosol loading*
	12.00-12.25	Albert Bleeker • Energy research Centre of the Netherlands, Petten, NL	*Linking ammonia emission reduction and air concentrations and depositions of reduced nitrogen in Europe*
	13.00	Lunch	
	Session 2 • Agriculture and emissions of ammonia Chair: Oene Oenema • Wageningen University and Research Center, NL		
	14.30-15.05	Oene Oenema • Wageningen University and Research Center, Wageningen, NL	*Agriculture and reduced nitrogen: what goes in must come out*
	15.05-15.40	Viney Aneja • North Carolina State University, US	*Trends in agricultural ammonia emissions and ammonium concentrations in precipitation over the Southeast and Midwest United States*
	15.40-16.15	Ulrich Daemgen • Federal Agricultural Research Centre, Braunschweig, DE	*Emissions, atmospheric concentrations and bulk deposition of reduced nitrogen in Hesse, Germany - steps towards a comprehensive treatment of reactive nitrogen in the atmosphere*
	16.15-16.40	Coffee break	
	16.40-17.15	Mark Theobald • Centre for Ecology & Hydrology, Penicuik, Edinburgh, UK	*Ammonia emissions from large animal colonies*

Energy research Centre of the Netherlands

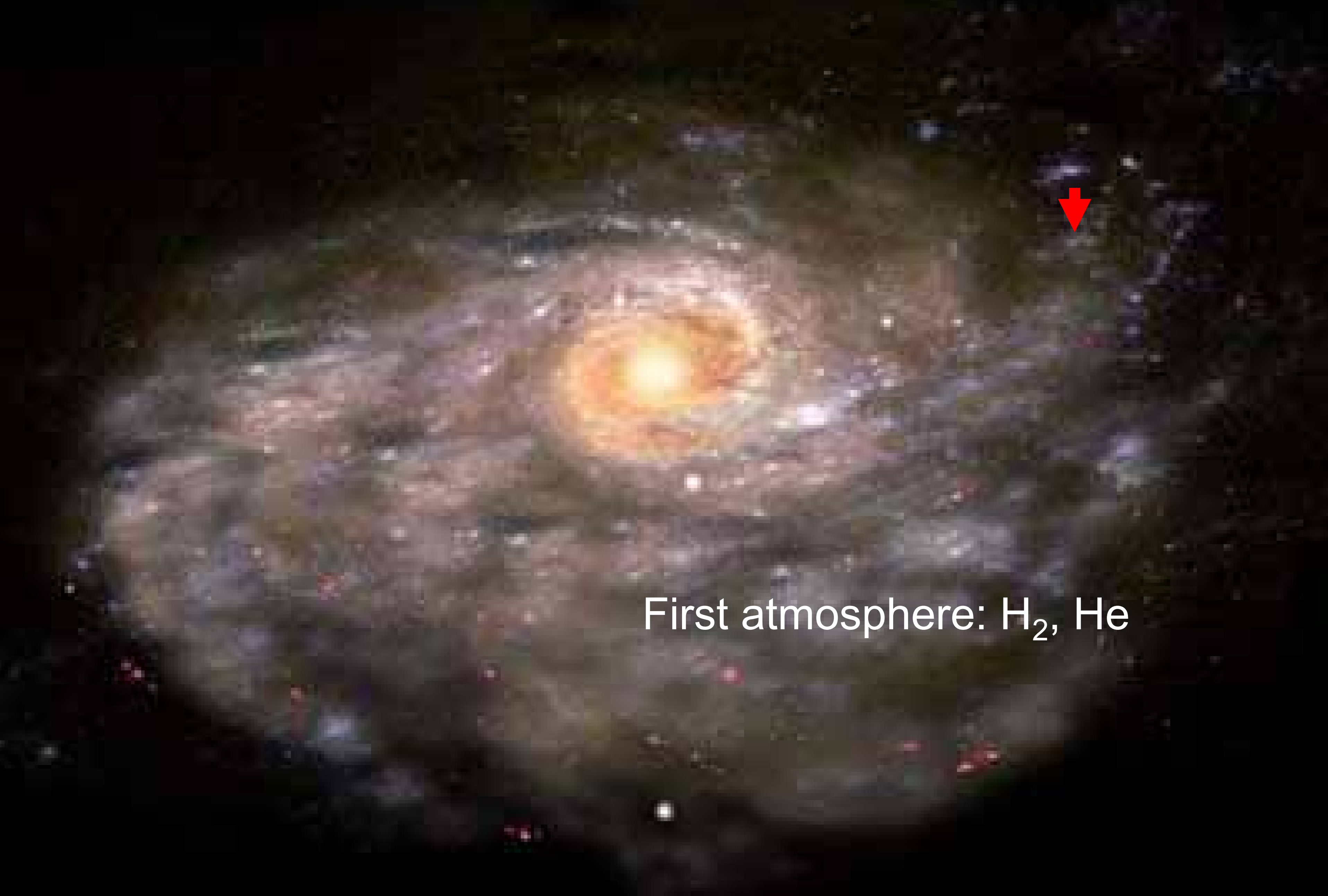
Reduced forms of Nitrogen in Ecology and the Environment

Jan Willem Erisman

Outline of presentation

- The earth system
- Reduced nitrogen in ecology
- Industrial production
- Environment
- N management
- Discussion items

Our milky way with a developing solar system (↓)

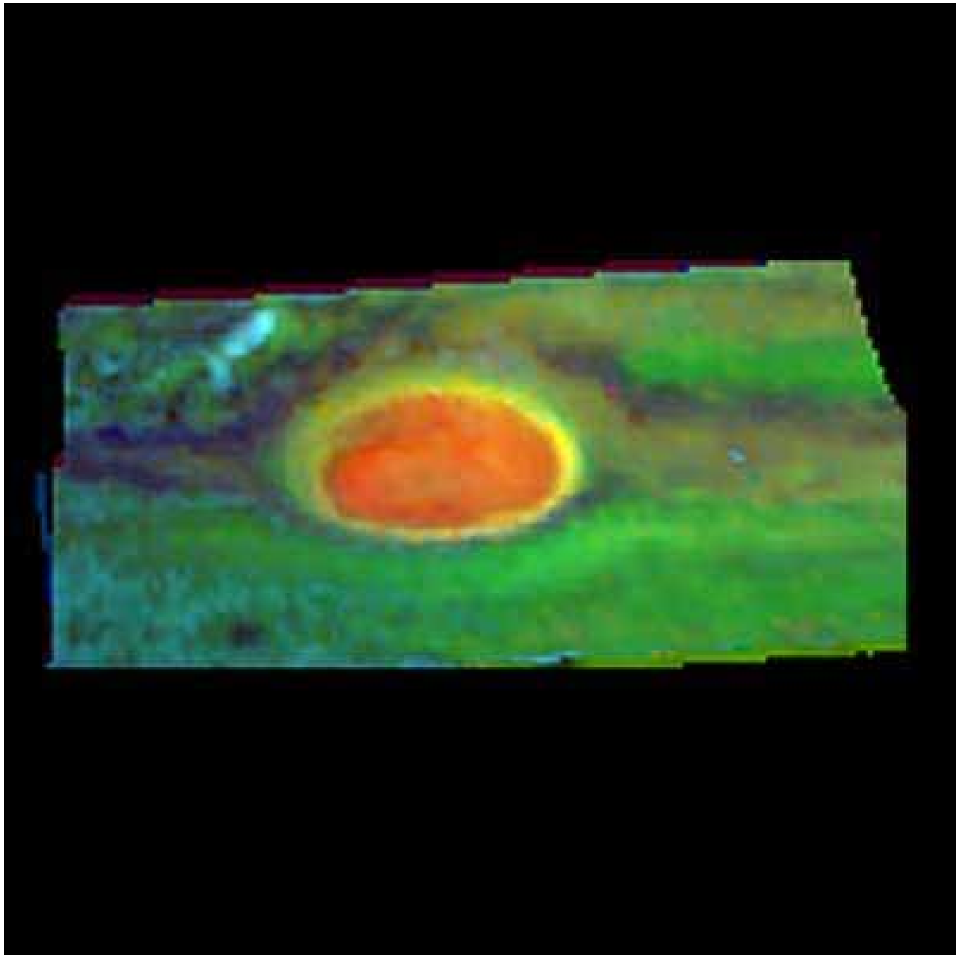


The earth began as a gas bulb, which slowly cooled down, which is still going on. Through this process the earth is shrinking.

The chemical climate of the earth started with gases from volcanic eruptions

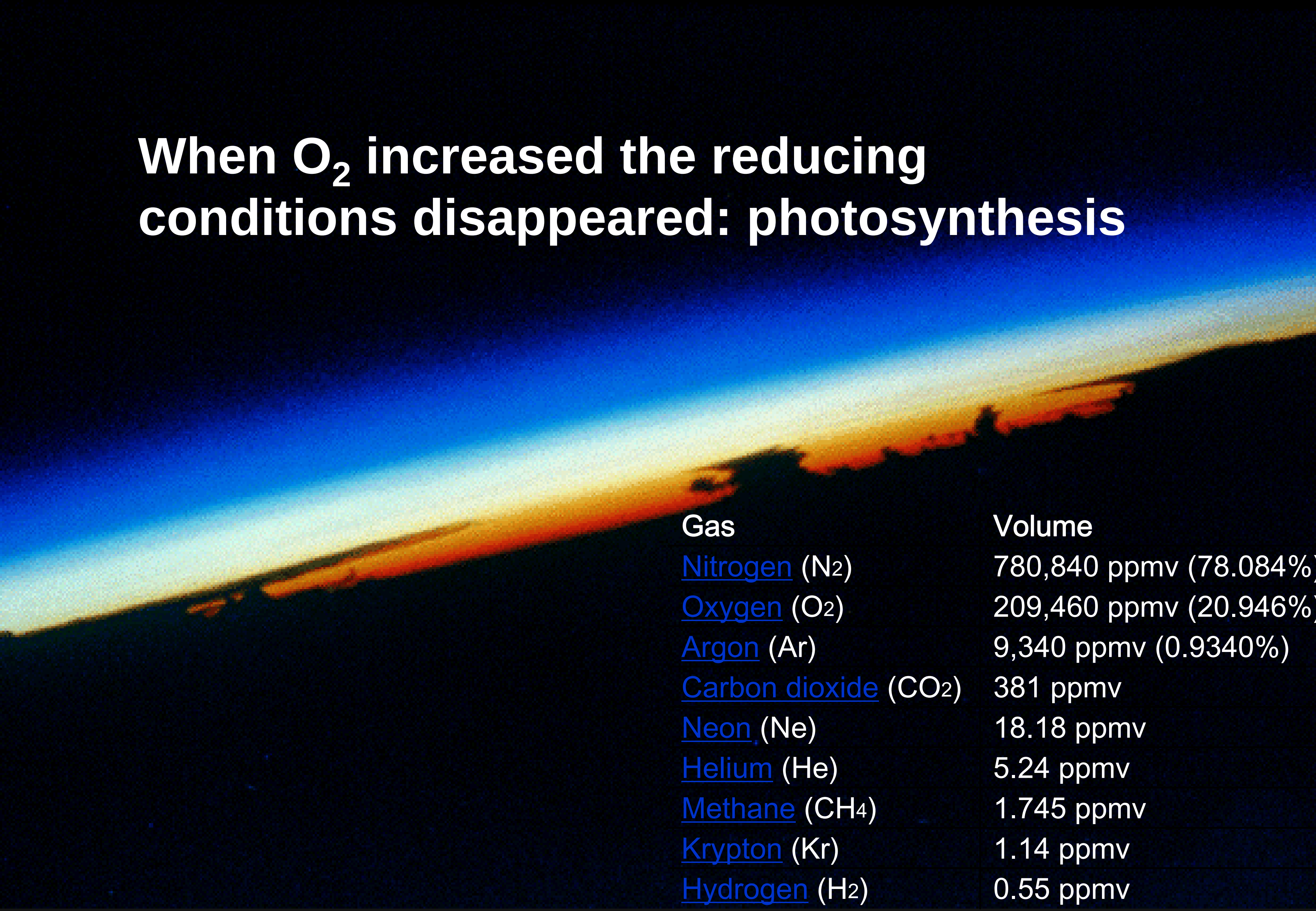
Second atmosphere: H_2O, CO_2, SO_2, CO, N_2, CH_4 and NH_3

Ammonia cloud on Jupiter



NASA, Galileo
June 26, 1996

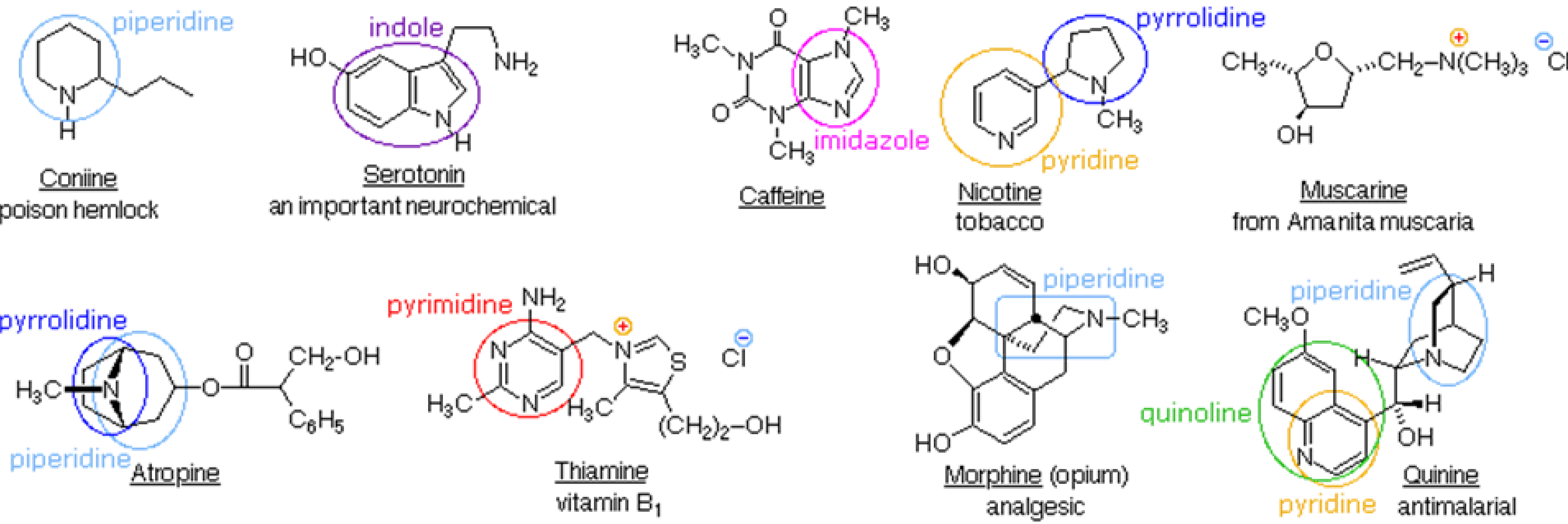
When O_2 increased the reducing conditions disappeared: photosynthesis



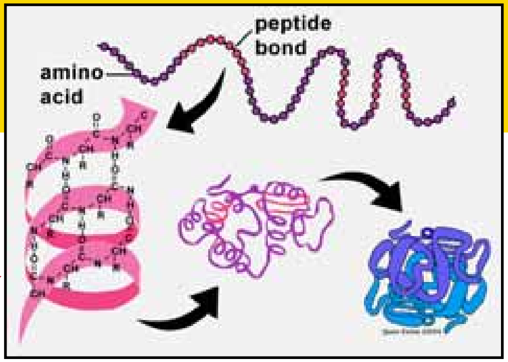
Gas	Volume
Nitrogen (N_2)	780,840 ppmv (78.084%)
Oxygen (O_2)	209,460 ppmv (20.946%)
Argon (Ar)	9,340 ppmv (0.9340%)
Carbon dioxide (CO_2)	381 ppmv
Neon (Ne)	18.18 ppmv
Helium (He)	5.24 ppmv
Methane (CH_4)	1.745 ppmv
Krypton (Kr)	1.14 ppmv
Hydrogen (H_2)	0.55 ppmv

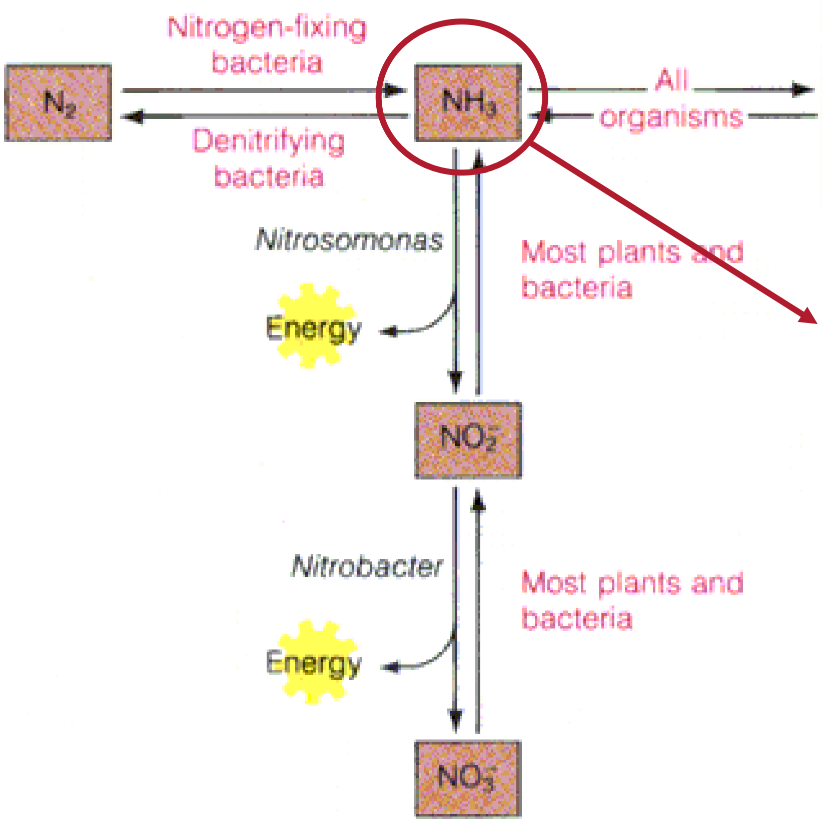
Reduced nitrogen in nature

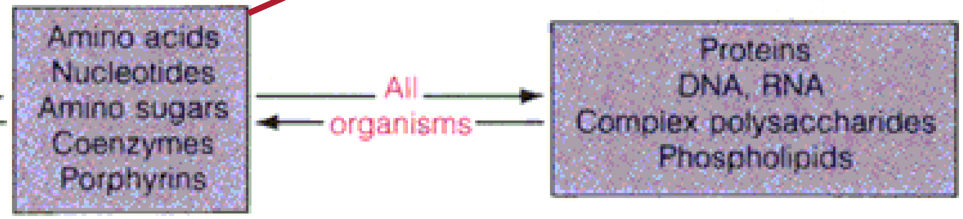
- Ammonia and ammonium salts
- The major amines in both air and rain are trimethylamine and methylamine, but dimethylamine, diethylamine and triethylamine.
- Life sustained by amino acids



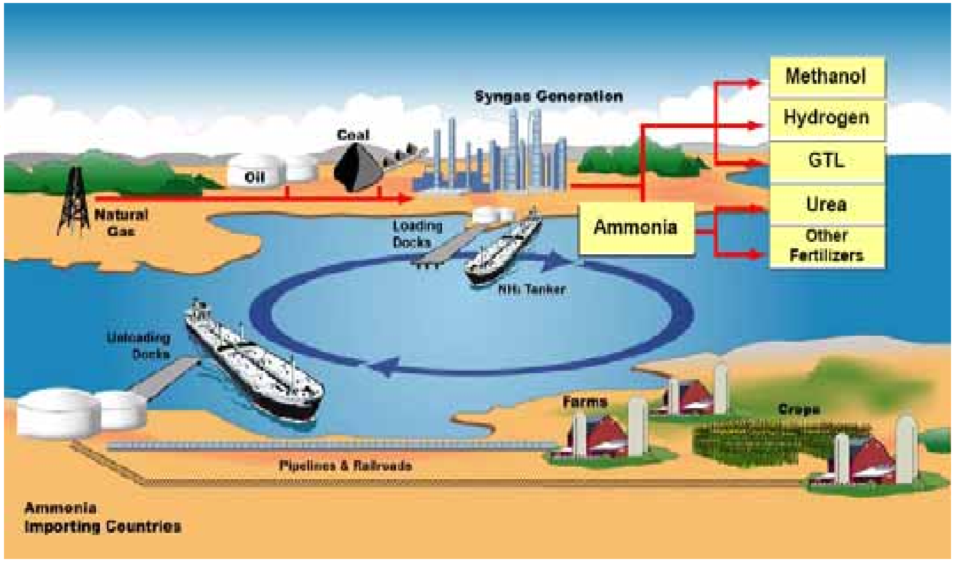
Key issues: life and production







World production (2004): 142 Millions MT/year

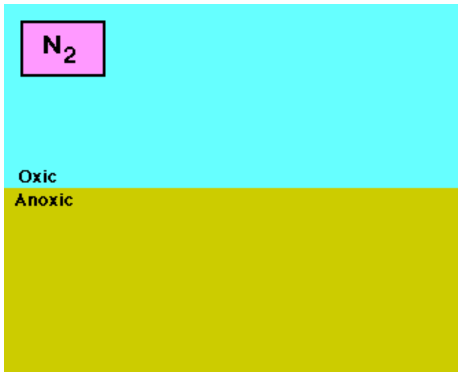


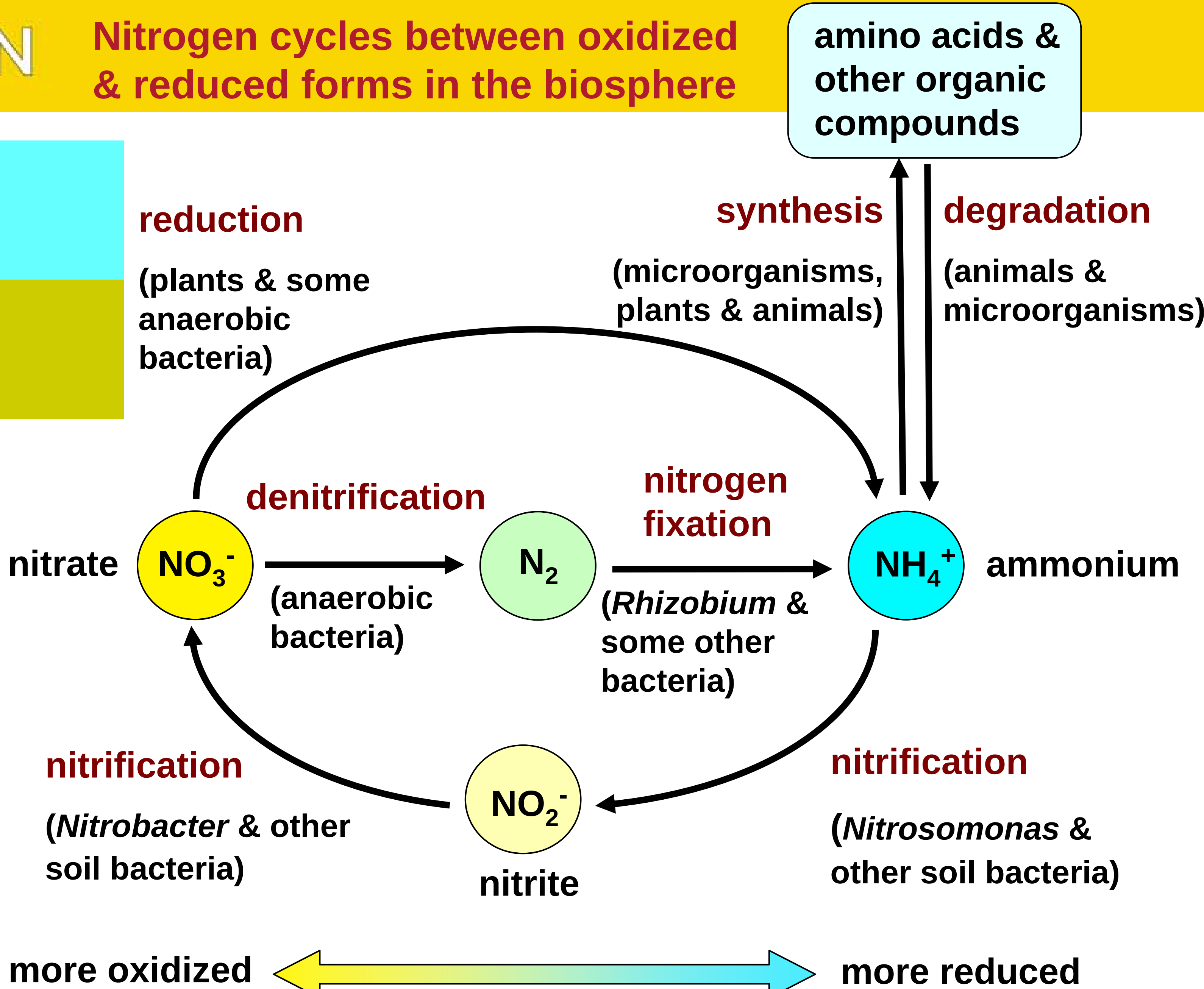
All organisms depend on NH_3

- **Insufficient protein in the diet may prevent the body from producing adequate levels of peptide hormones and structural proteins to sustain normal bodily functions**

…….. too little   ……. too much

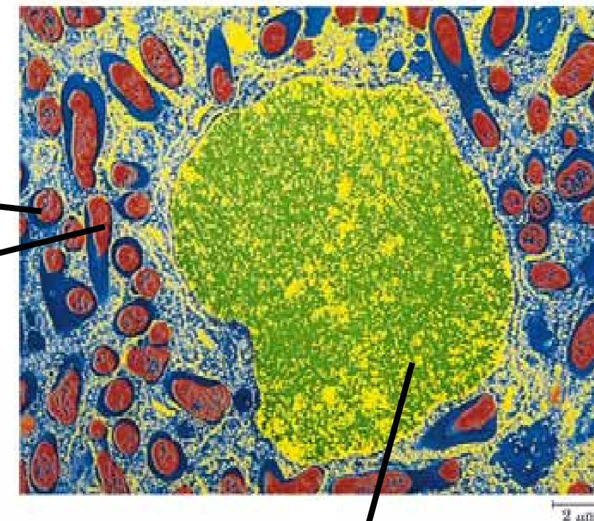
Nitrogen cycles between oxidized & reduced forms in the biosphere



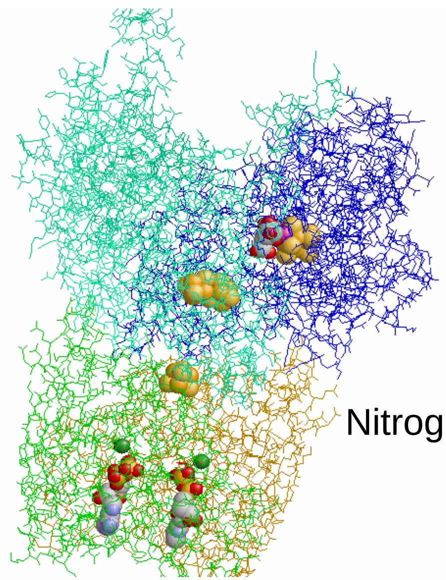


Nodules on the roots of leguminous plants fix N_2 via bacteria containing nitrogenase

bacteroids
(rod-like bacteria)



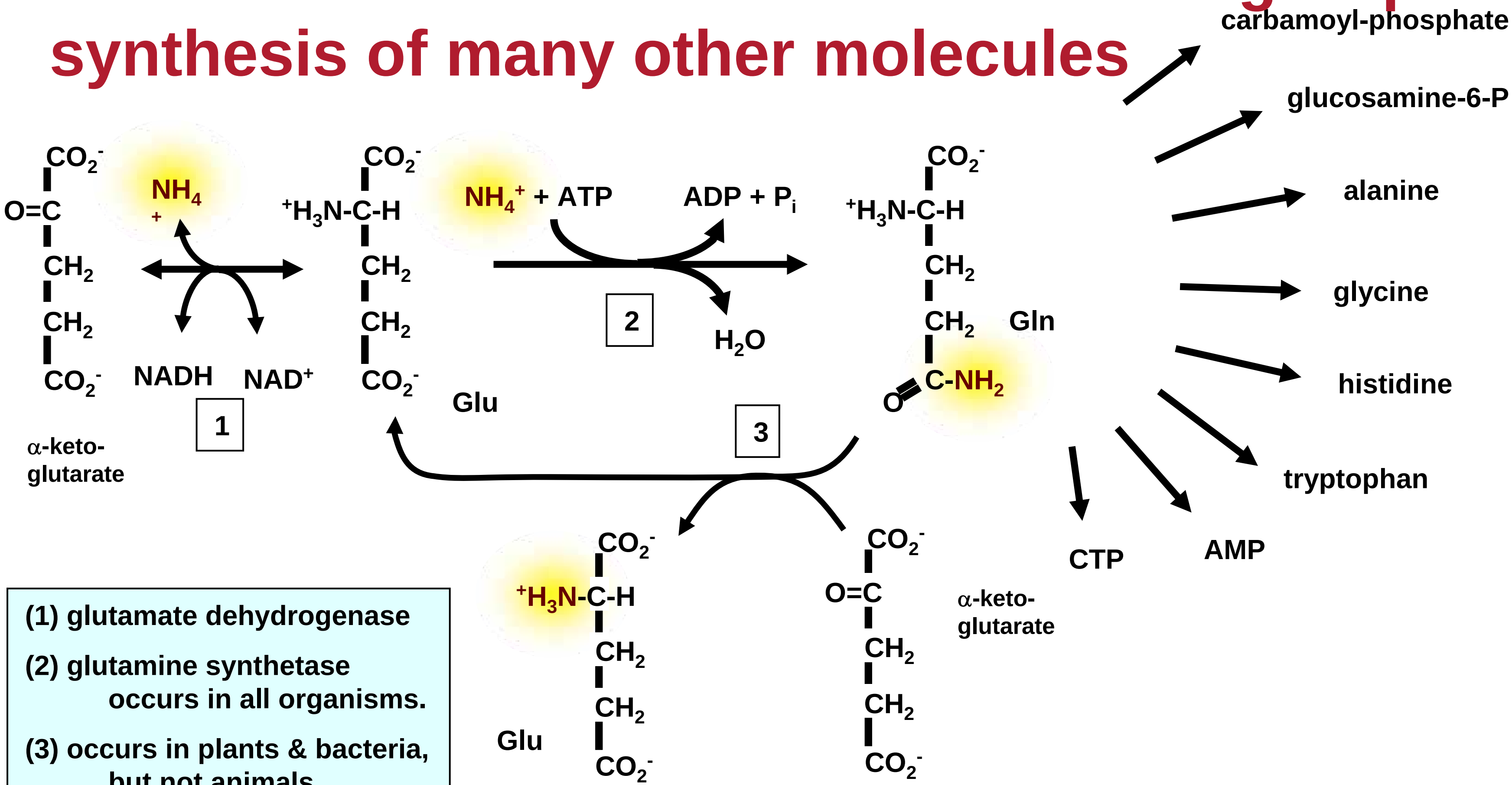
plant cell nucleus



Nitrogenase from *Azobacter vinelandii*

Lehninger

Glutamine serves as a donor of amine groups for synthesis of many other molecules



(1) glutamate dehydrogenase

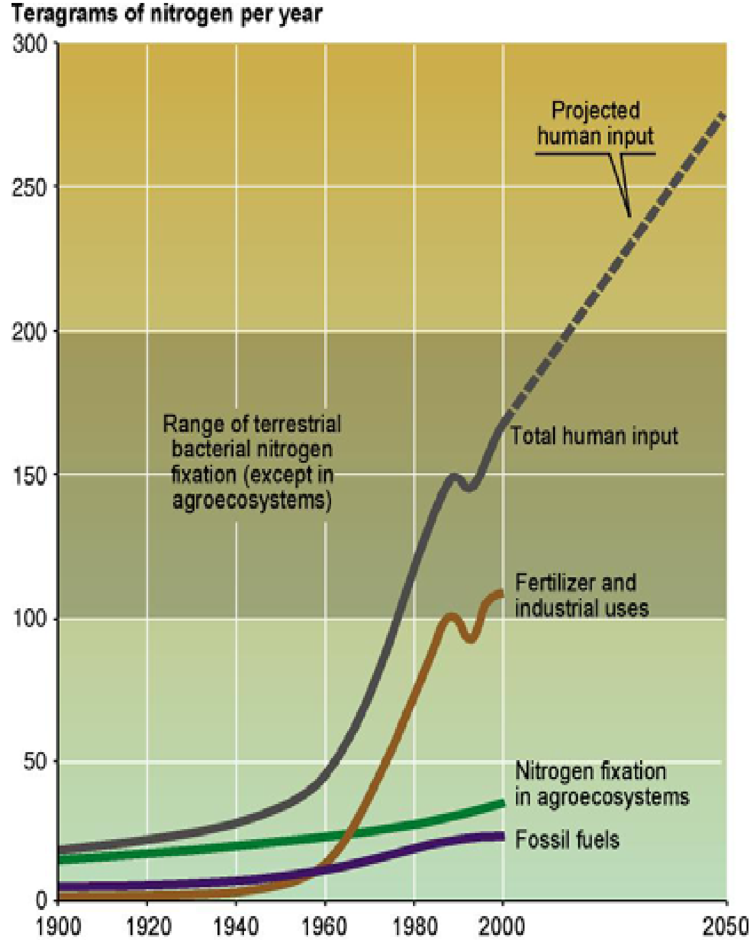
(2) glutamine synthetase occurs in all organisms.

(3) occurs in plants & bacteria, but not animals

In most terrestrial animals, Gln also carries ammonia in the blood to the liver & kidneys for excretion as urea.

NH_3 Creation by Nature and Humans

- Since 1960:
  - Flows of biologically available nitrogen in terrestrial ecosystems doubled
  - > 50% of all the synthetic nitrogen fertilizer ever used has been used since 1985
- Humans produce as much biologically available N as all natural pathways and this may grow a further 65% by 2050

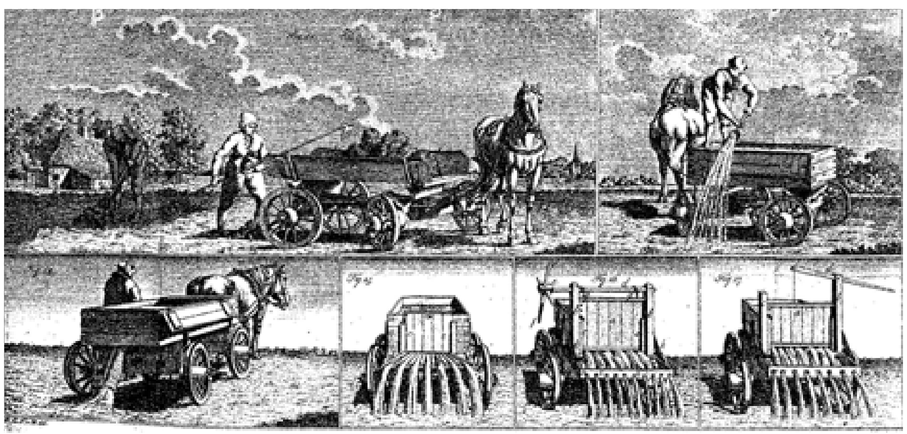


Source: Millennium Ecosystem Assessment

Human-produced Reactive Nitrogen

Historical development

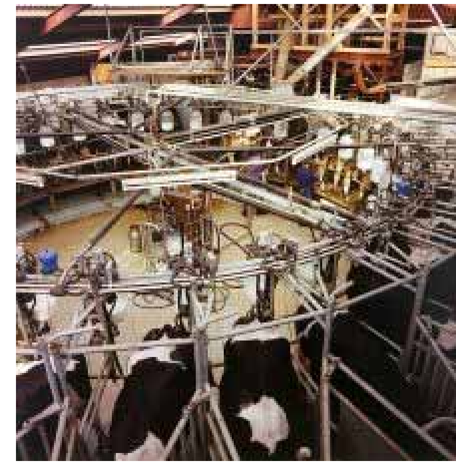
Closed nutrient cycles



Manure = food

Fertilizer

Increased production



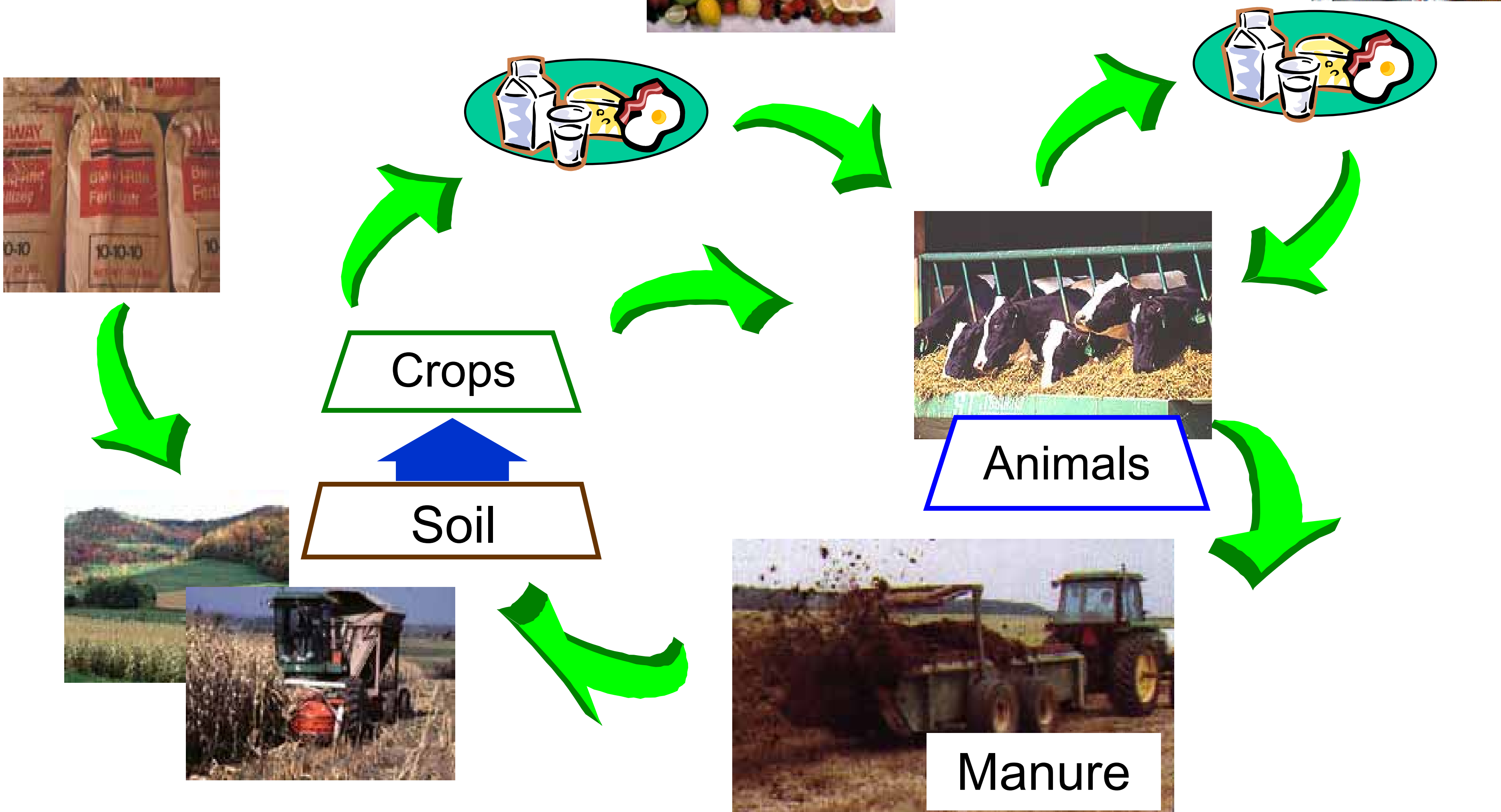
Intensive livestock breeding

Intensification of agriculture





Nitrogen Cycle



The fate of fertilizer Nitrogen

N Fertilizer Produced

100

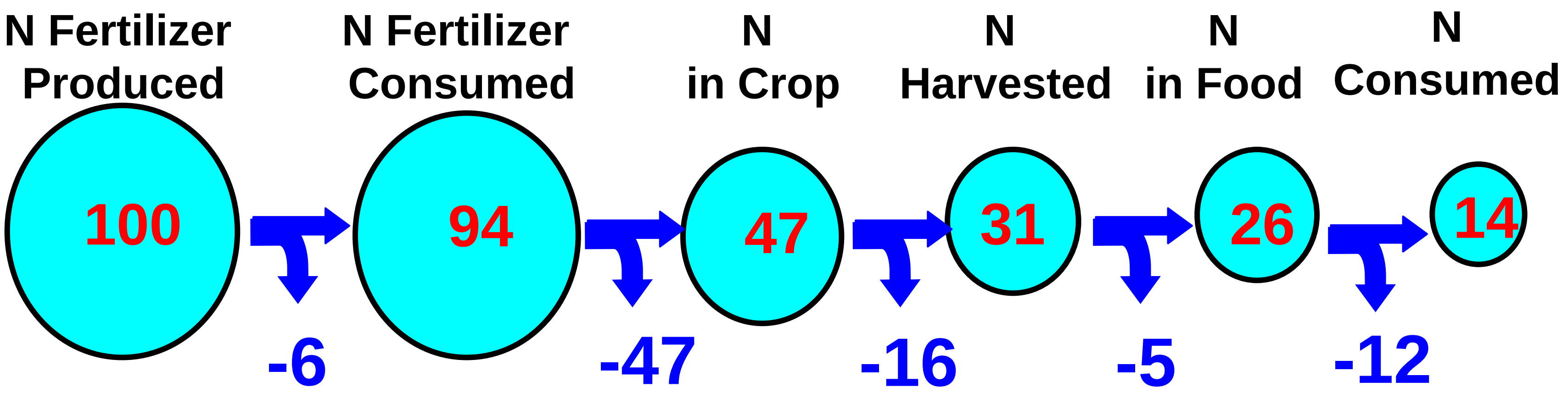
Galloway JN and Cowling EB. 2002

The fate of fertilizer Nitrogen

14% of the N produced in the Haber-Bosch process enters the human mouth……….

Galloway JN and Cowling EB. 2002

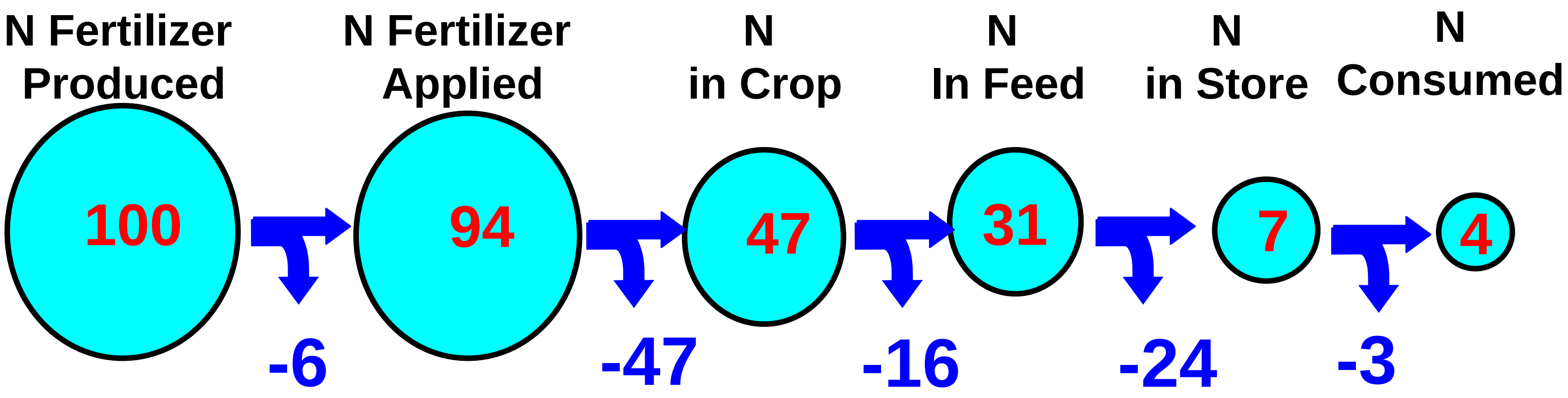
The fate of fertilizer Nitrogen



14% of the N produced in the Haber-Bosch process enters the human mouth……….if you are a vegetarian.

Galloway JN and Cowling EB. 2002

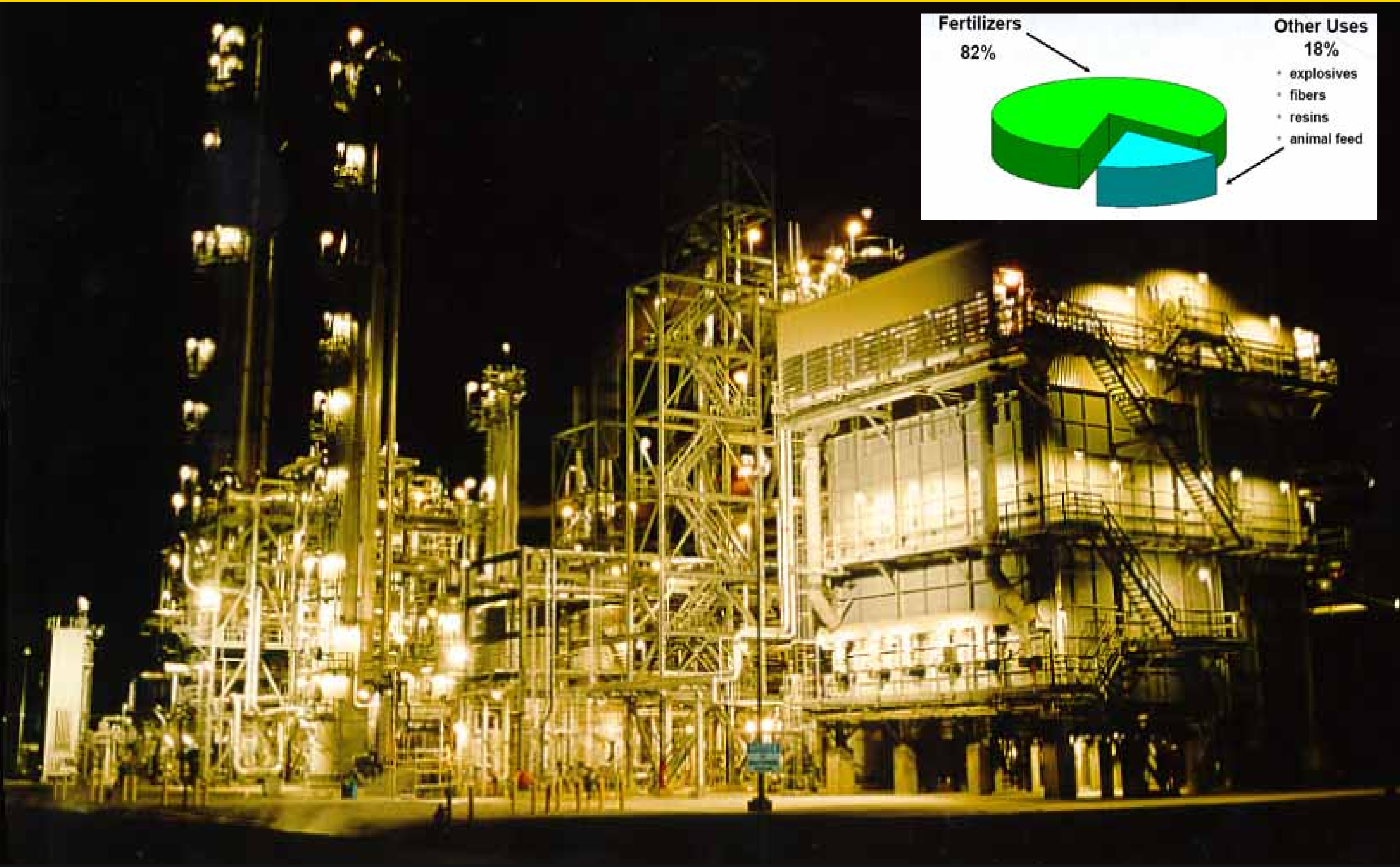
The fate of fertilizer Nitrogen



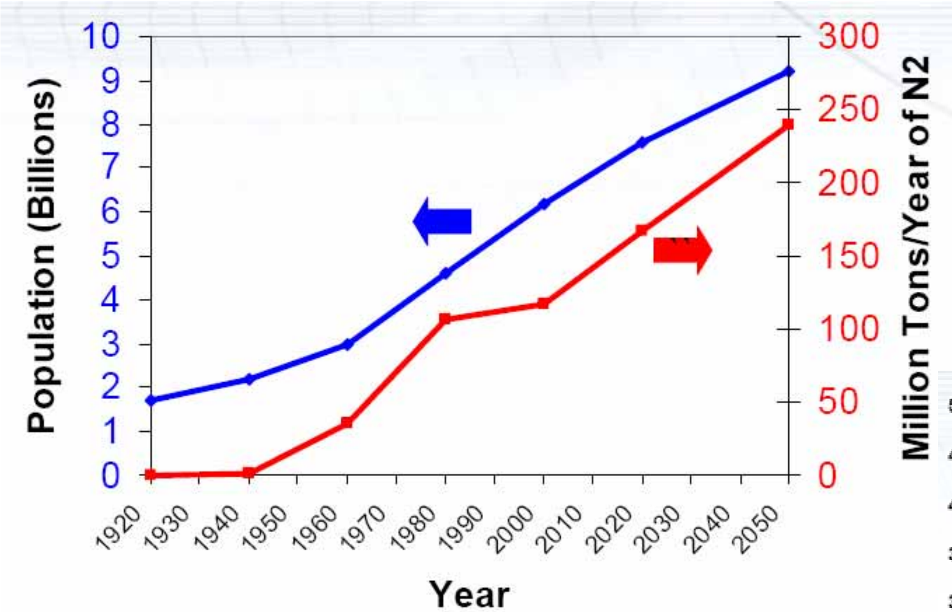
4% of the N produced in the Haber-Bosch process and used for animal production enters the human mouth.

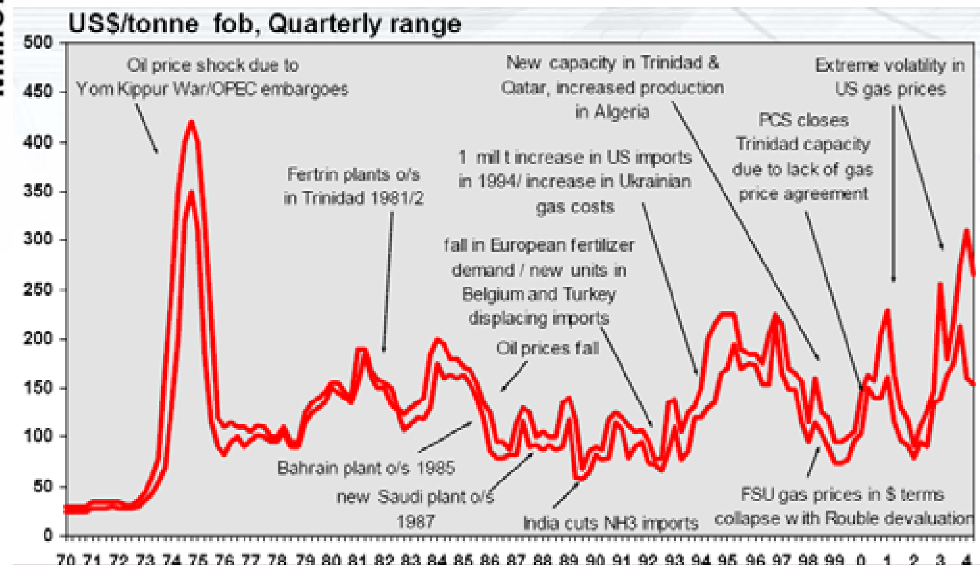
Galloway JN and Cowling EB. 2002

Industrial production of NH_3



Production volume and price





Ammonia products

Household application

Fibers

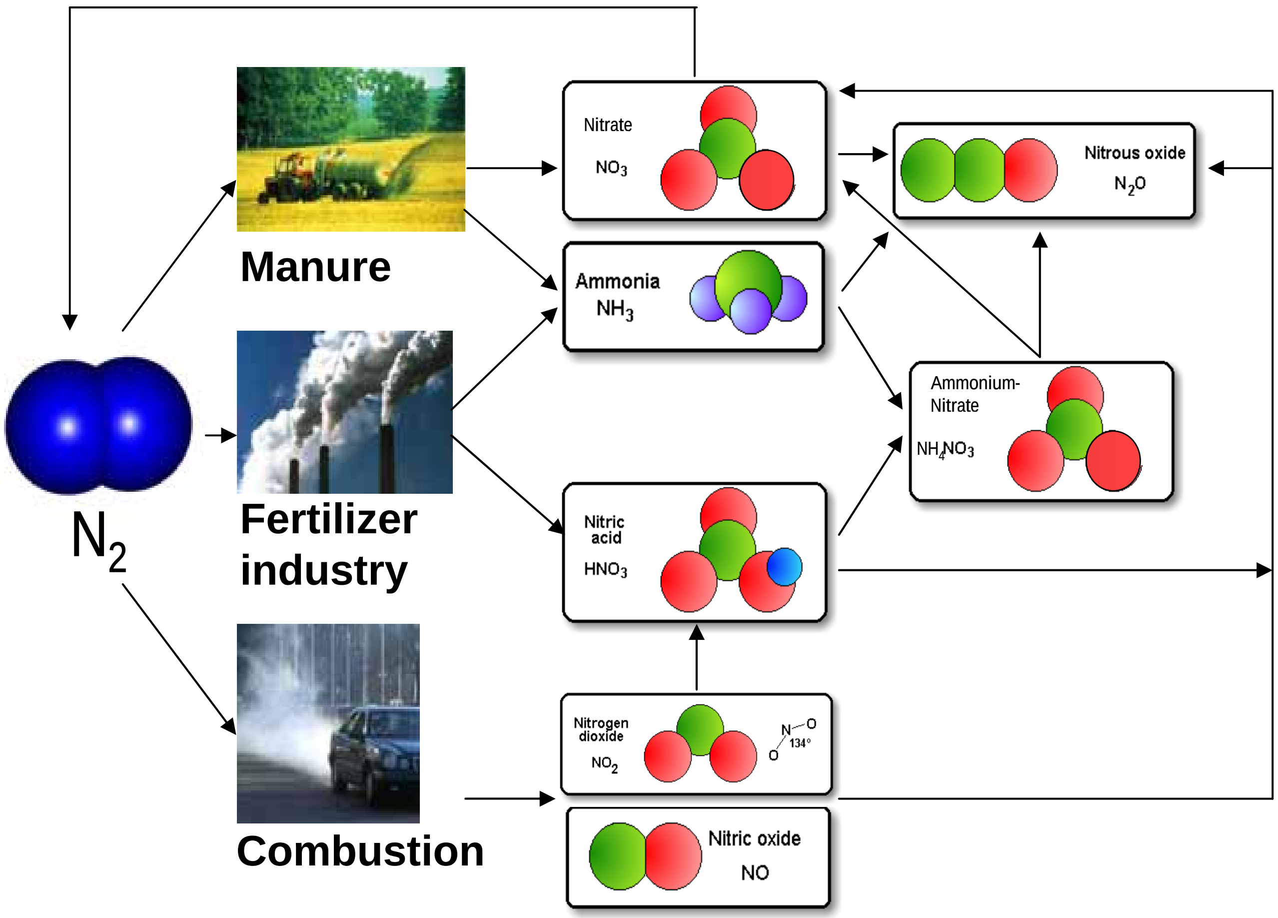
Aquarium test kid

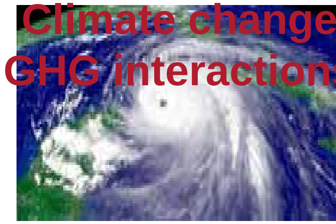
Explosives

Industrial ammonia

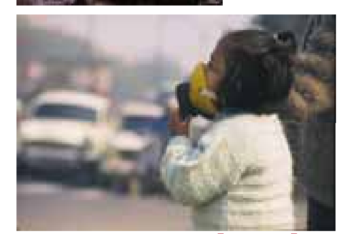
Ammonia levels	Health effects
– 5ppm	Olfactory detection
– 20-25ppm	Eye irritation
– ~ 1,500ppm	Cough and froth at the mouth
– 5,000ppm	Deadly

Nitrogen excess





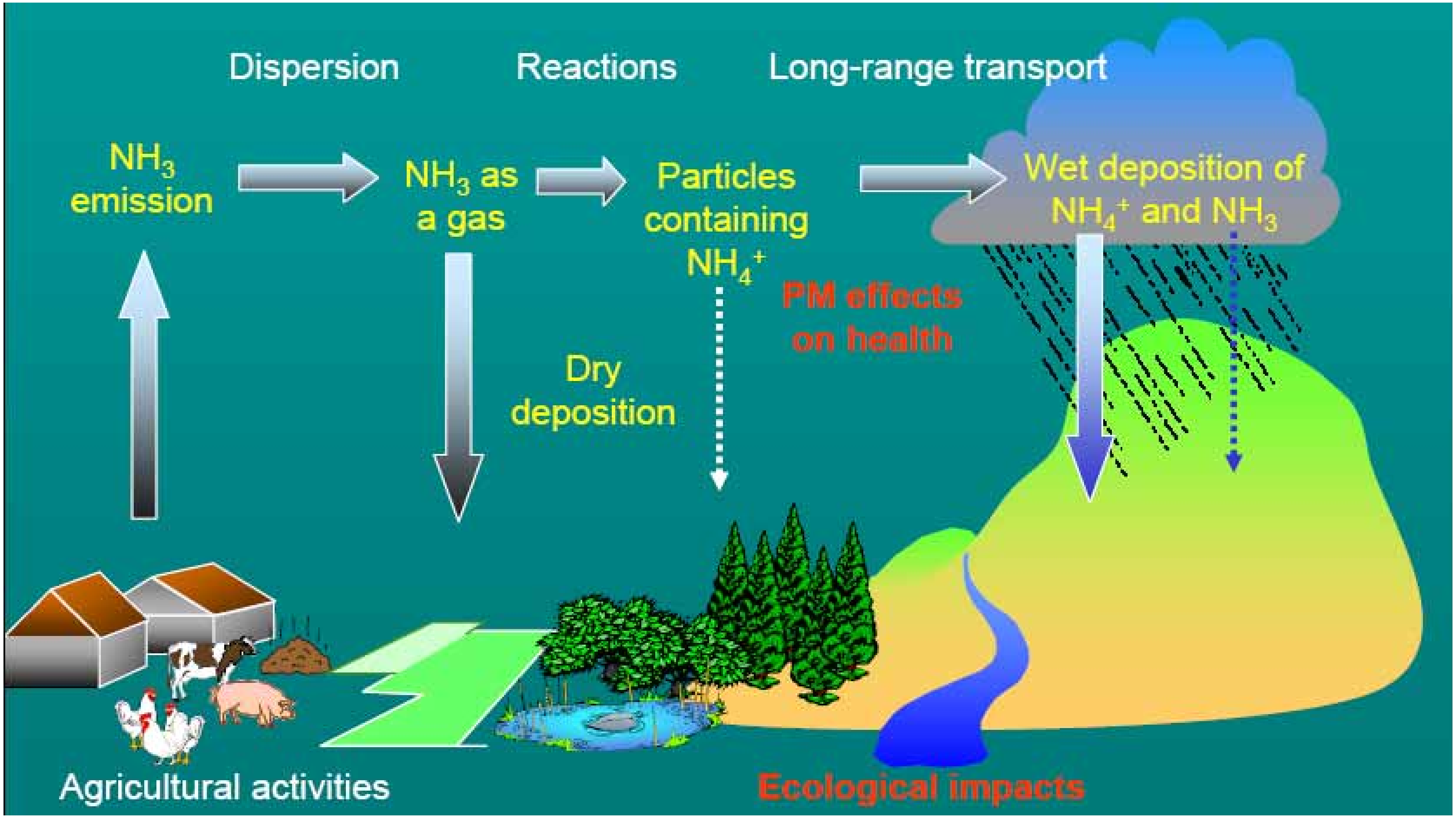
Materials and cultural heritage



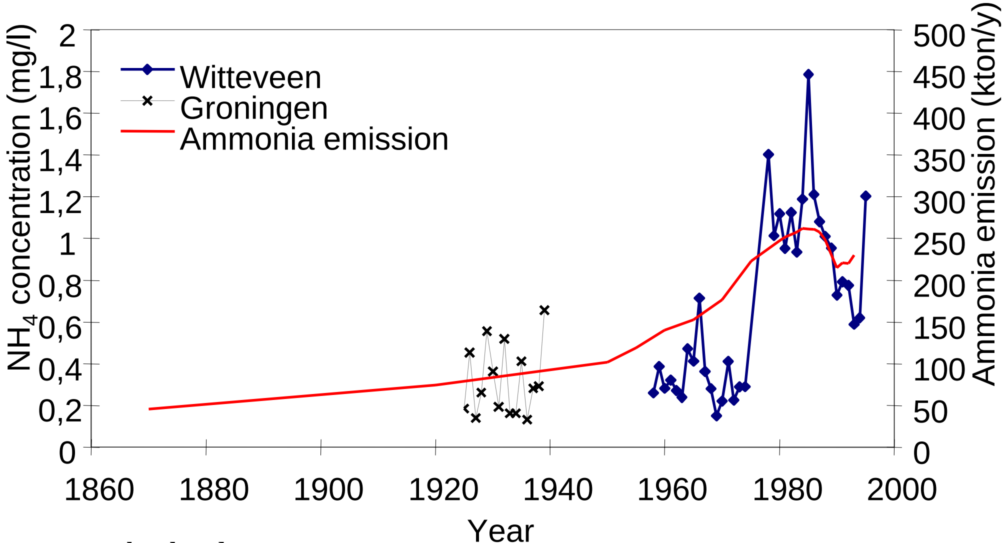
Human and animal health

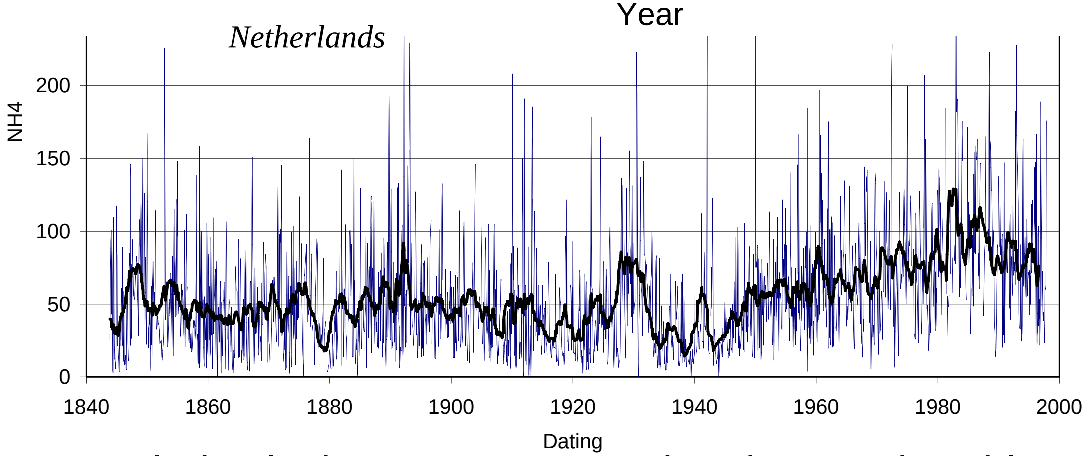
Sources Chemical/physical interactions Effects

Ammonia in the atmosphere



Paleo records and wet deposition





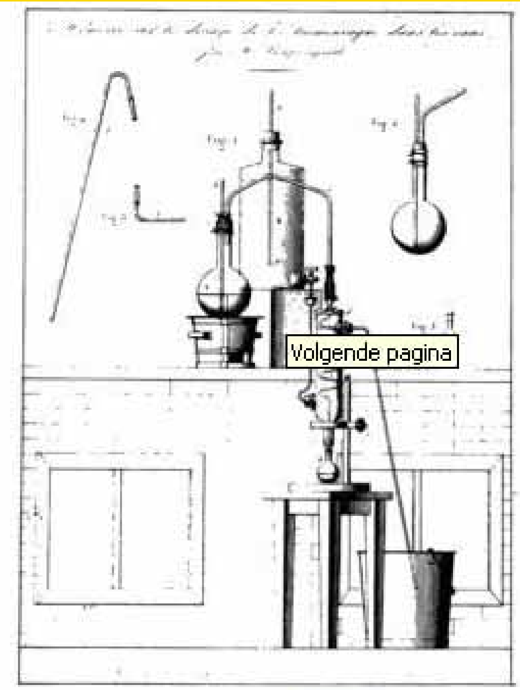
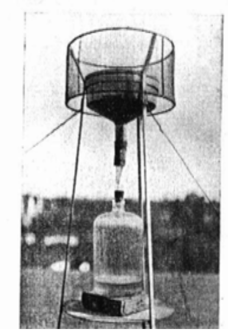
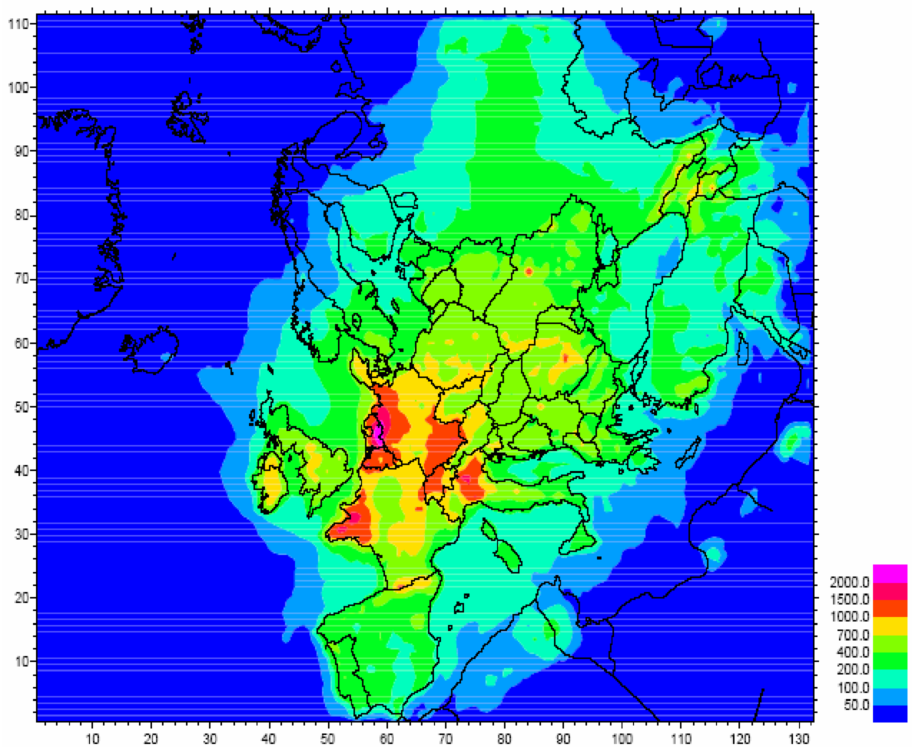


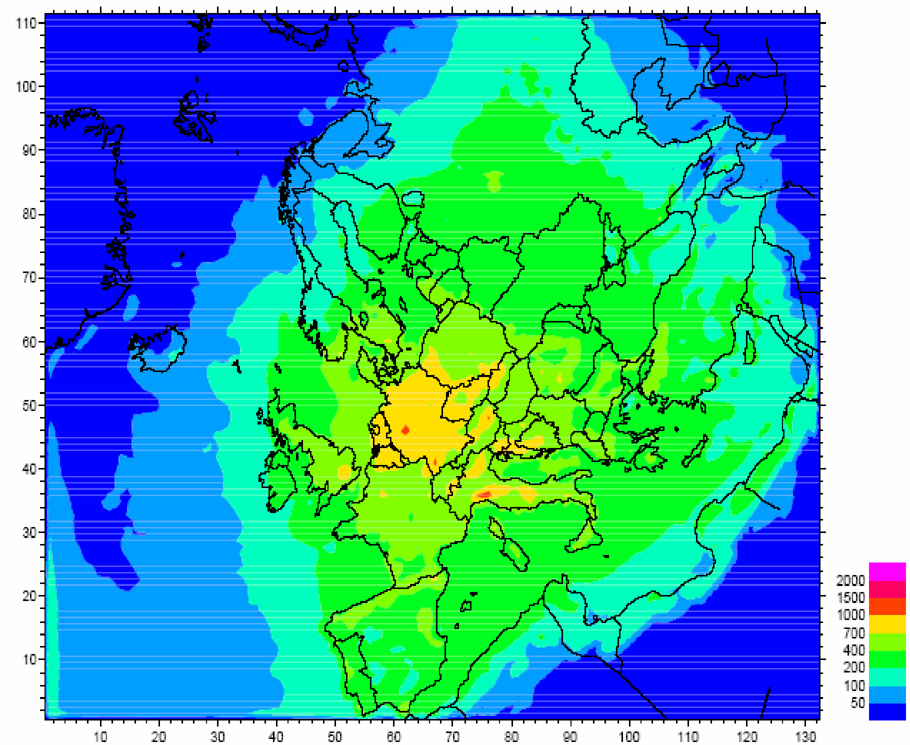
FIG. 11. Boussingault's ammonia apparatus (Boussingault, 1853a (*ADC*): pl. i).



East Rongbuk Glacier, Mt. Everest, Chemistry and Stable Isotope Data *Hou Shugui, et al., 2003*

Deposition maps of Europe





Reduced nitrogen (NHx)
1 – 20 kg/ha

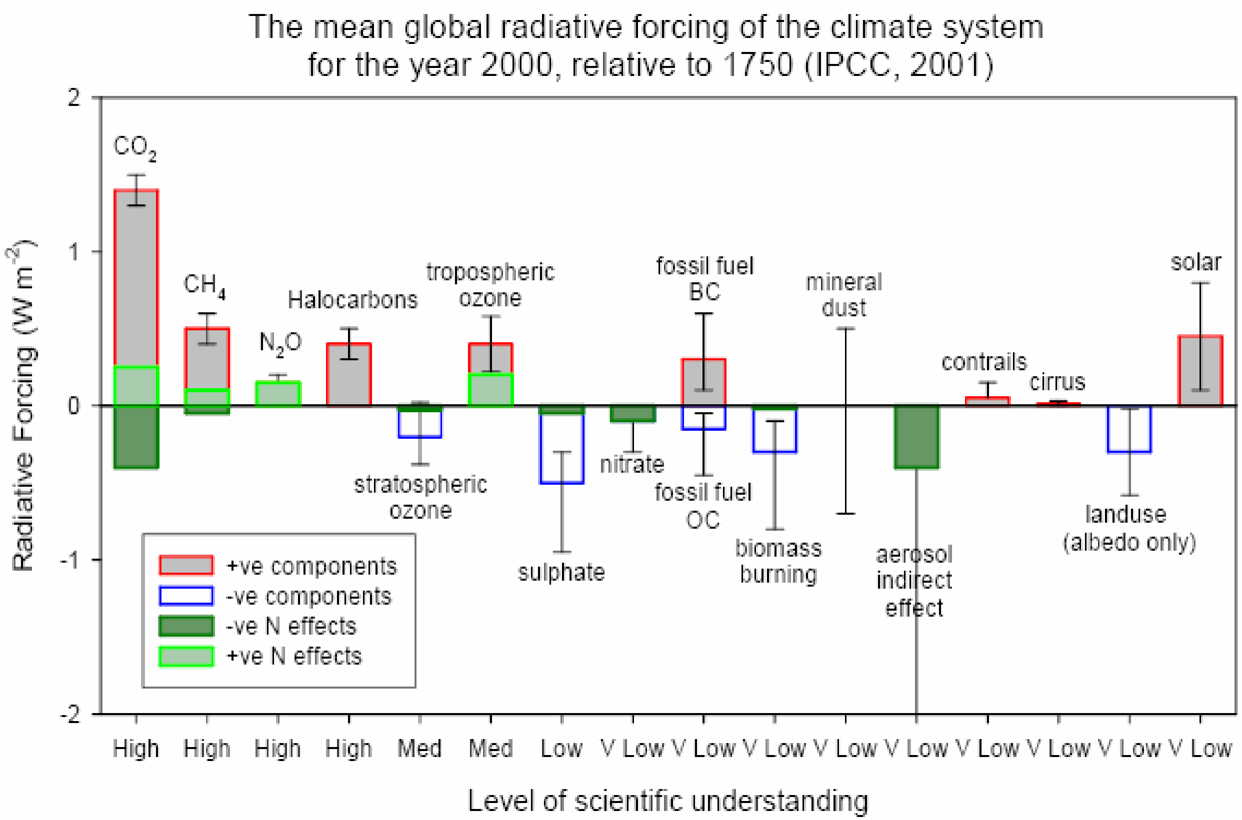
Oxidised nitrogen (NOx)
1 – 20 kg/ha

Source: EMEP

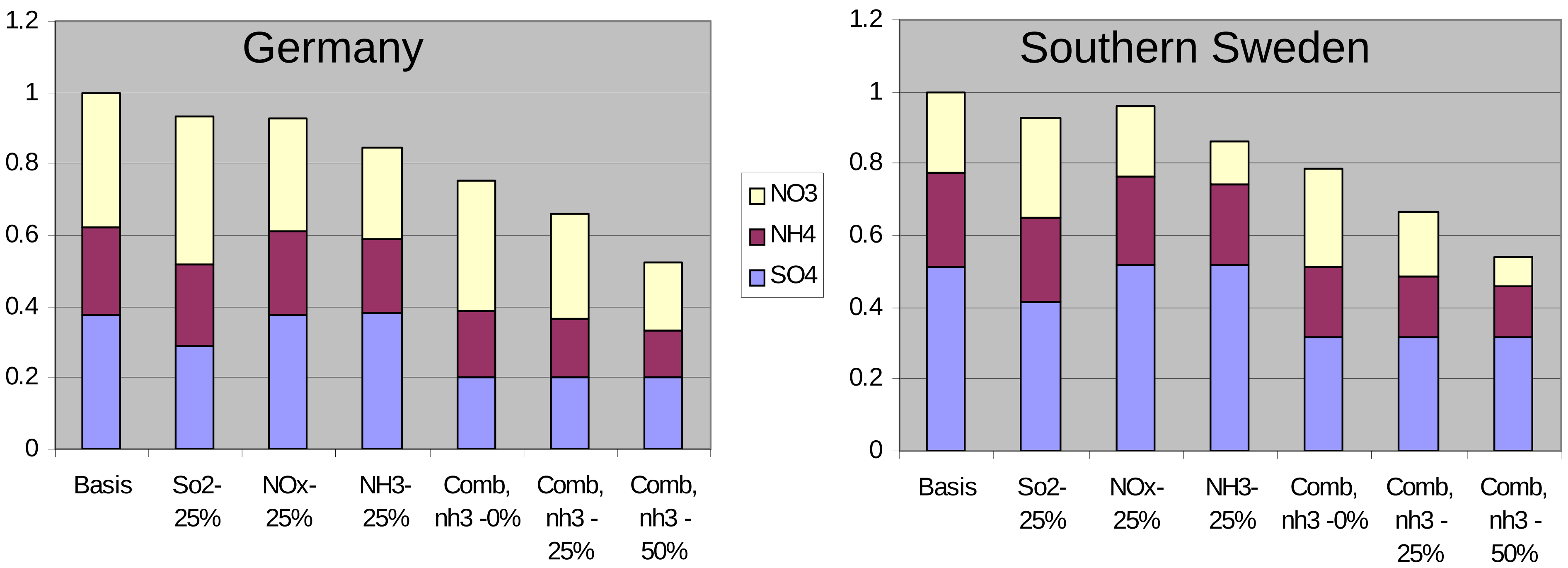
Effects on the environment

- Human health: PM, NO_x/O_3, NO_3 drinking water, plagues, pests and diseases
- Ecosystems: direct effects, plagues, pests and diseases, loss of biodiversity, plant/forest vitality, ecosystem functioning
- (Ground)water pollution
- Eutrophication: Gulf of Mexico Hypoxia Zone.
- Global warming (N_2O) and cooling (aerosols)
- GHG interactions affecting sinks
- Reduces visibility (haze);

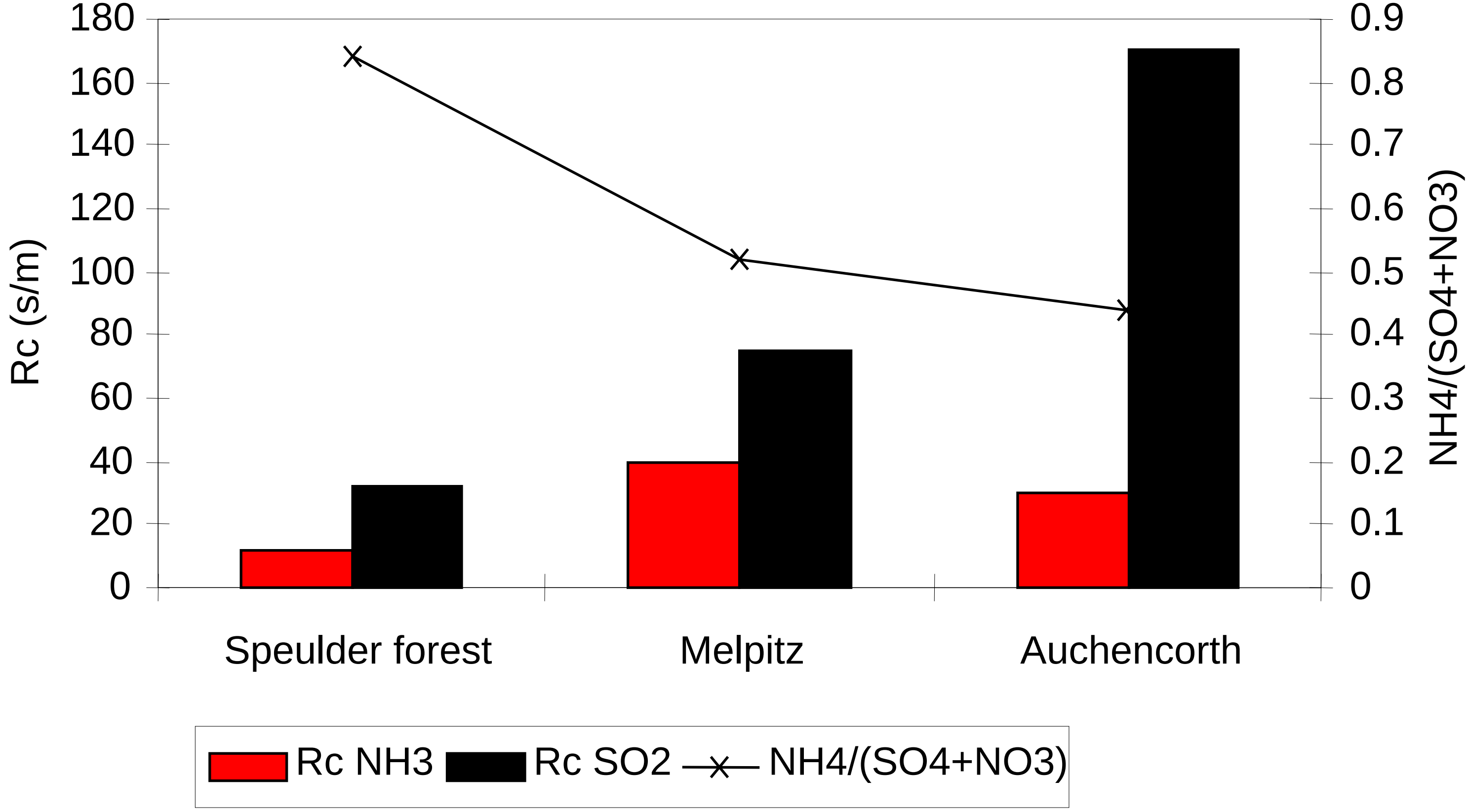
Radiative forcing and Nitrogen



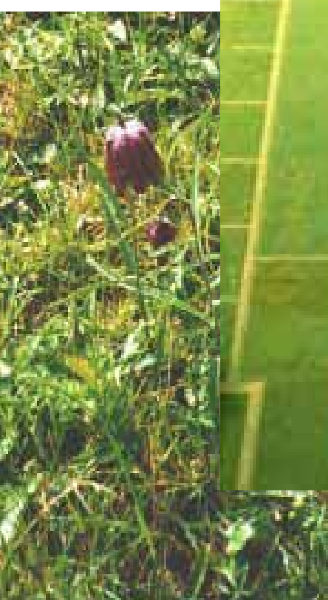
Effect of NH_3 reductions on secondary PM



Regulator for other processes, e.g. co-deposition between SO_2 and NH_3



Park Grass experiment, Rothamsted since 1856



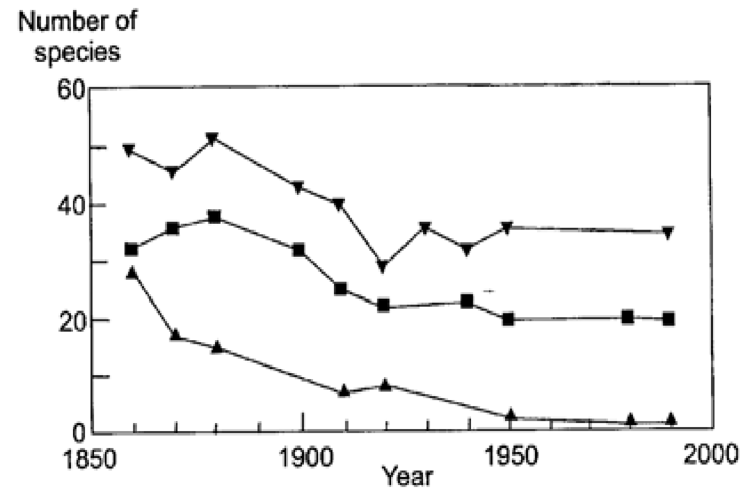
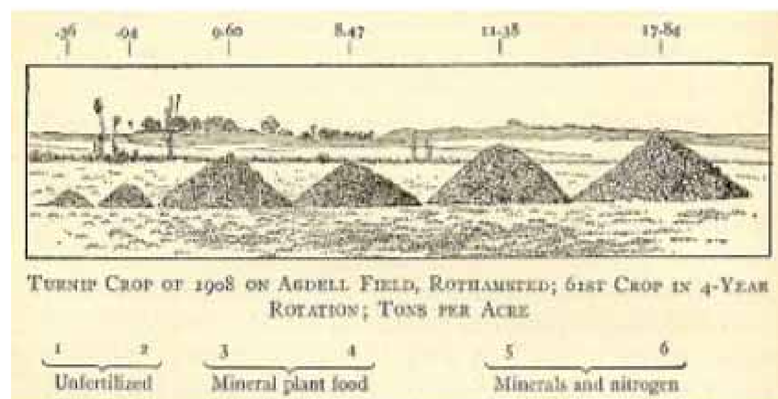


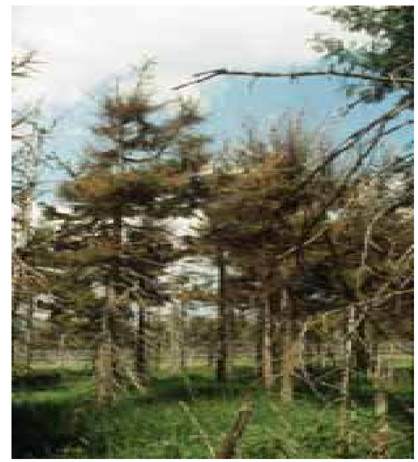
Figure 4. Changes in the number of species in the Rothamsted Park Grass Continuous Hay Experiment (Goulding et al., 1998). Unfertilized, ▼; sodium nitrate, plus P, K and Mg, ■; ammonium sulfate alone, ▲.



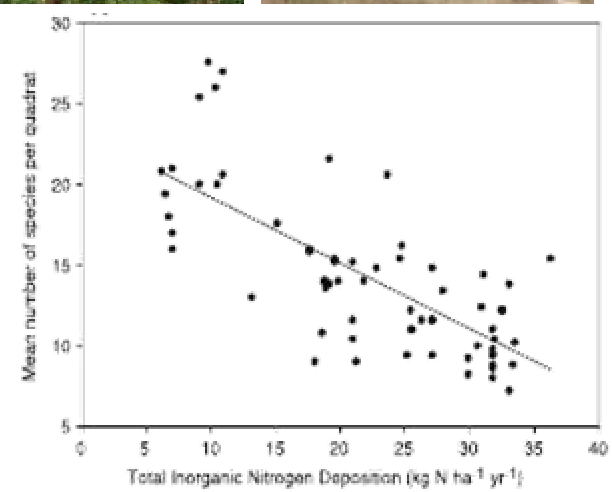
TURNIP CROP OF 1908 ON AGDELL FIELD, ROTHAMSTED; 61ST CROP IN 4-YEAR ROTATION; TONS PER ACRE

Effects of reactive nitrogen in the environment



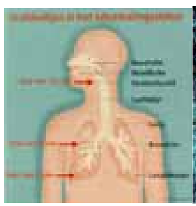


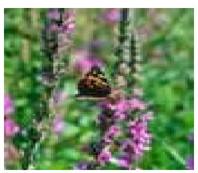
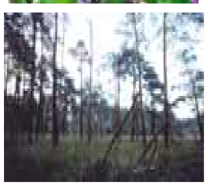
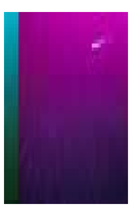
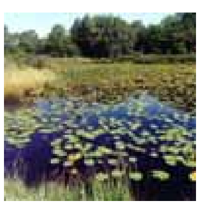




Cascade effect of reactive nitrogen (excess)





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<tr><th>Hours</th><th>days</th><th>Weeks</th><th>months</th><th>years</th><th>decades</th><th>centuries</th></tr>
<tr><td colspan="2">air concentrations
visibility</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Deposition</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">health (acute)</td><td></td><td colspan="2">health (chronic)</td><td></td><td></td></tr>
<tr><td></td><td colspan="3">aquatic (episodic)</td><td colspan="2">aquatic (chronic)</td><td></td></tr>
<tr><td colspan="3">plant responses</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="3">Vegetation changes
soil processes</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">soil nutrient reserves</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">forest ecosystem
health</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">Carbon sequestration</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">materials</td></tr>
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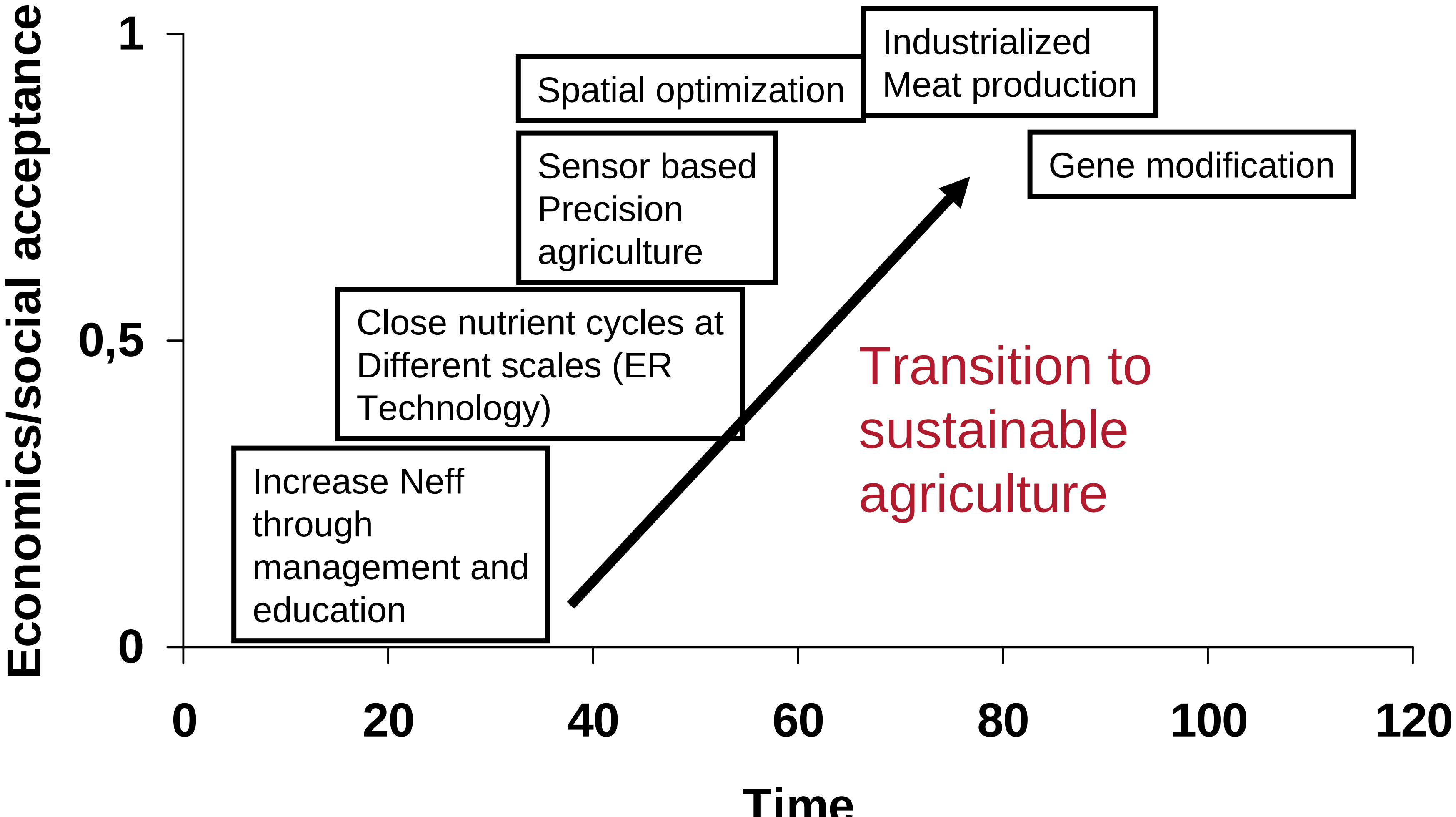
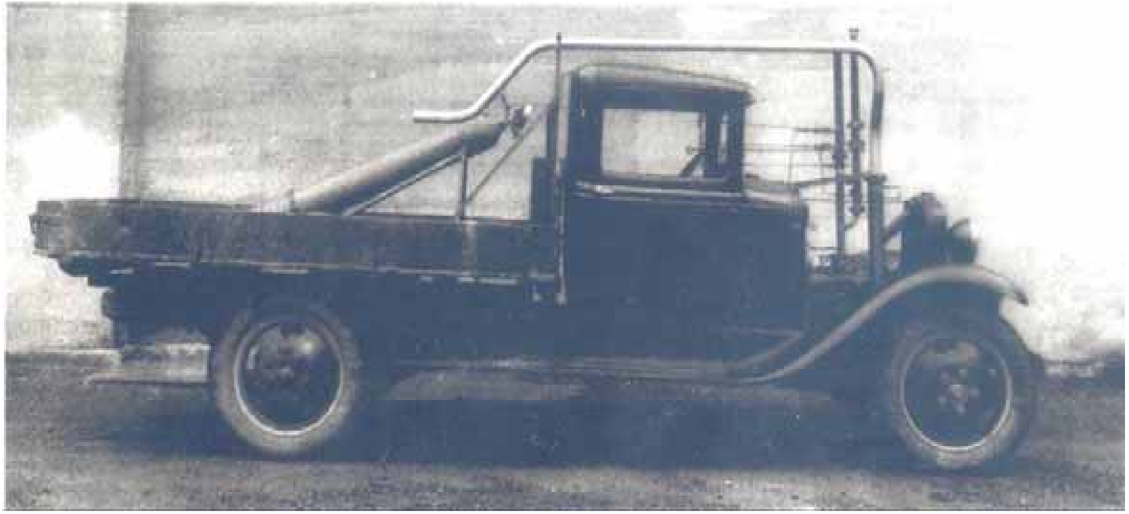
Effective measures



New items for reduced nitrogen

- Increasing demand of fertilizer: food, biofuels
- NH_3 as a transport fuel?



Ammonia fuelled car,
Rjukan 1933