The role of the biosphere in air quality and climate

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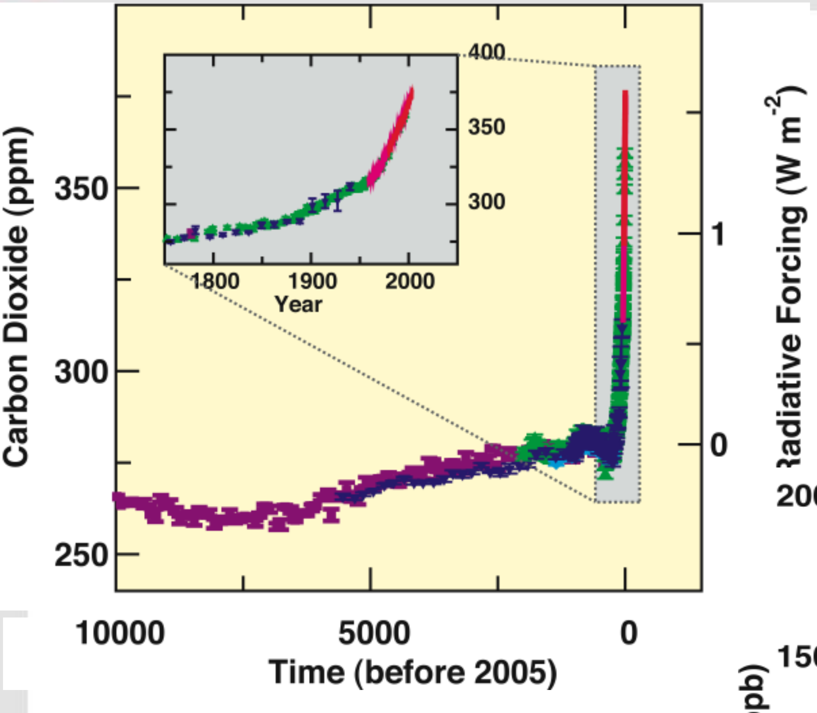
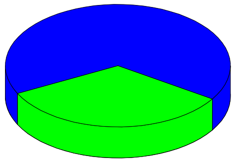
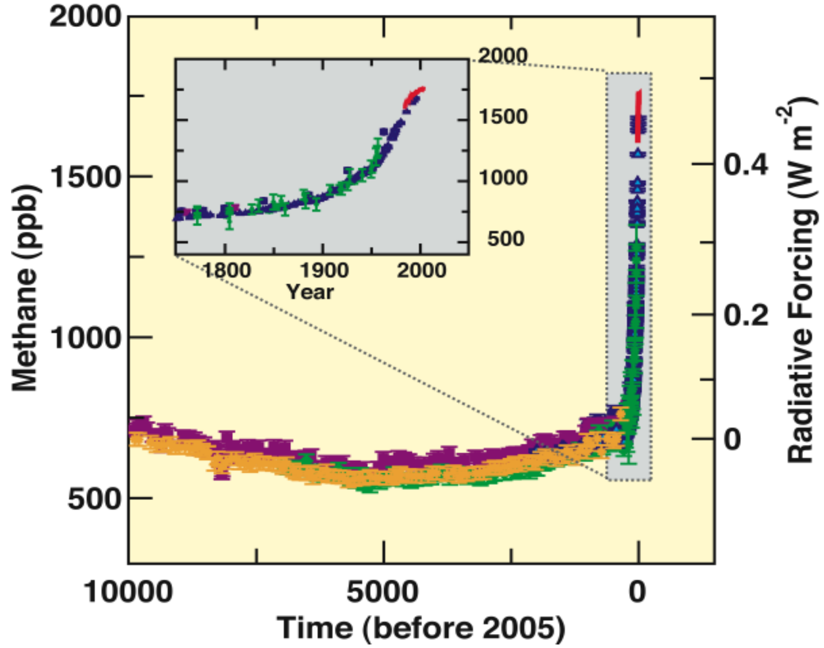
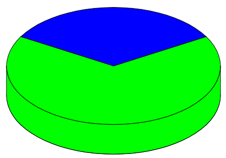
Why to study biosphere-atmosphere interactions when talking about climate change?



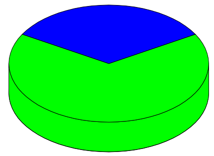


CO_2



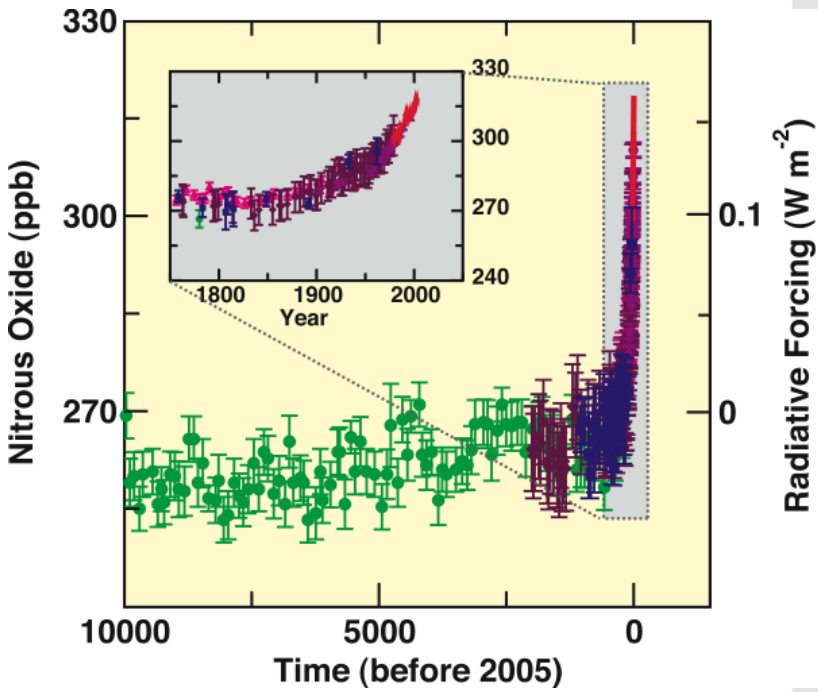


CH_4

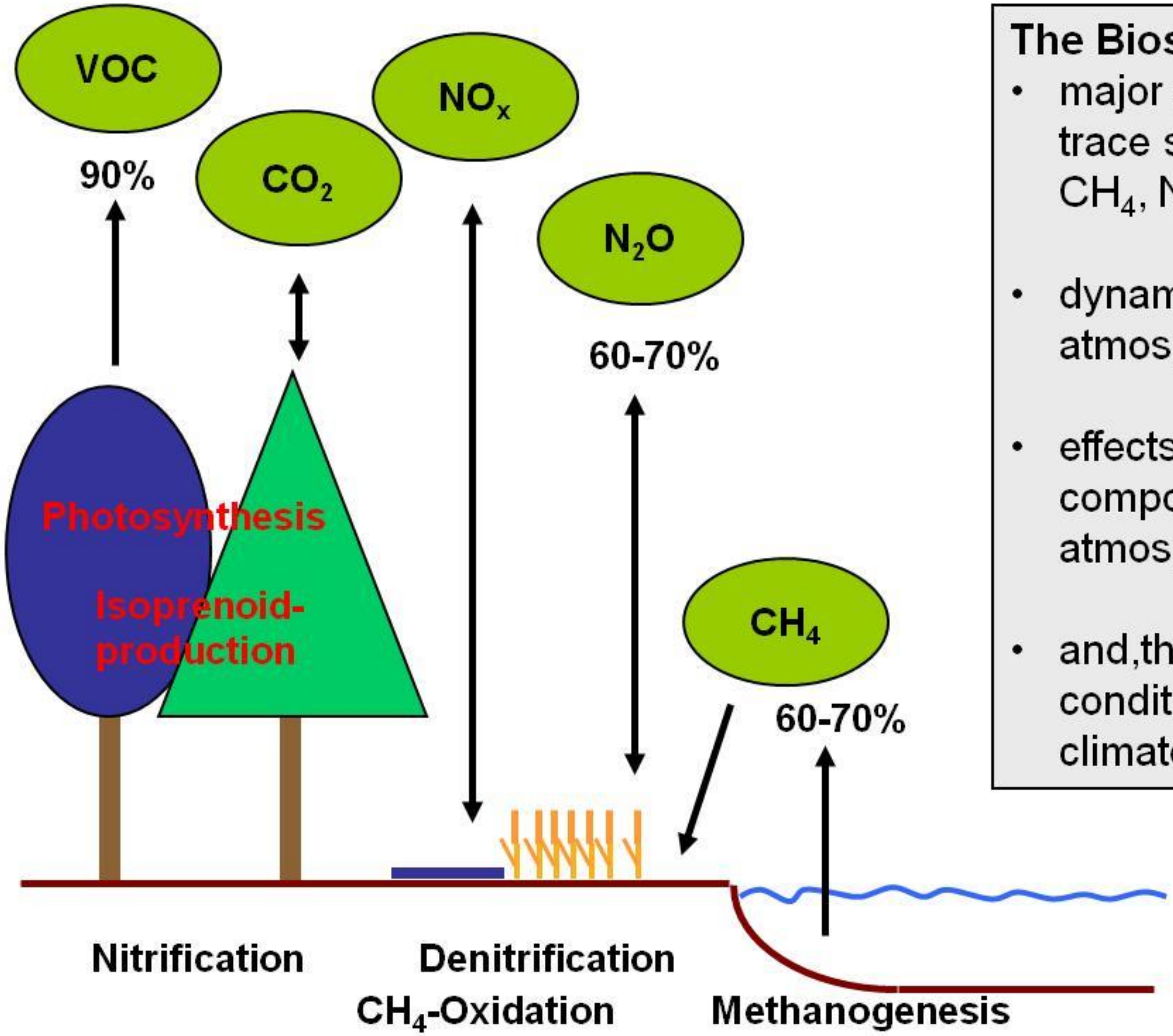


N_2O

Soils: 60-70%

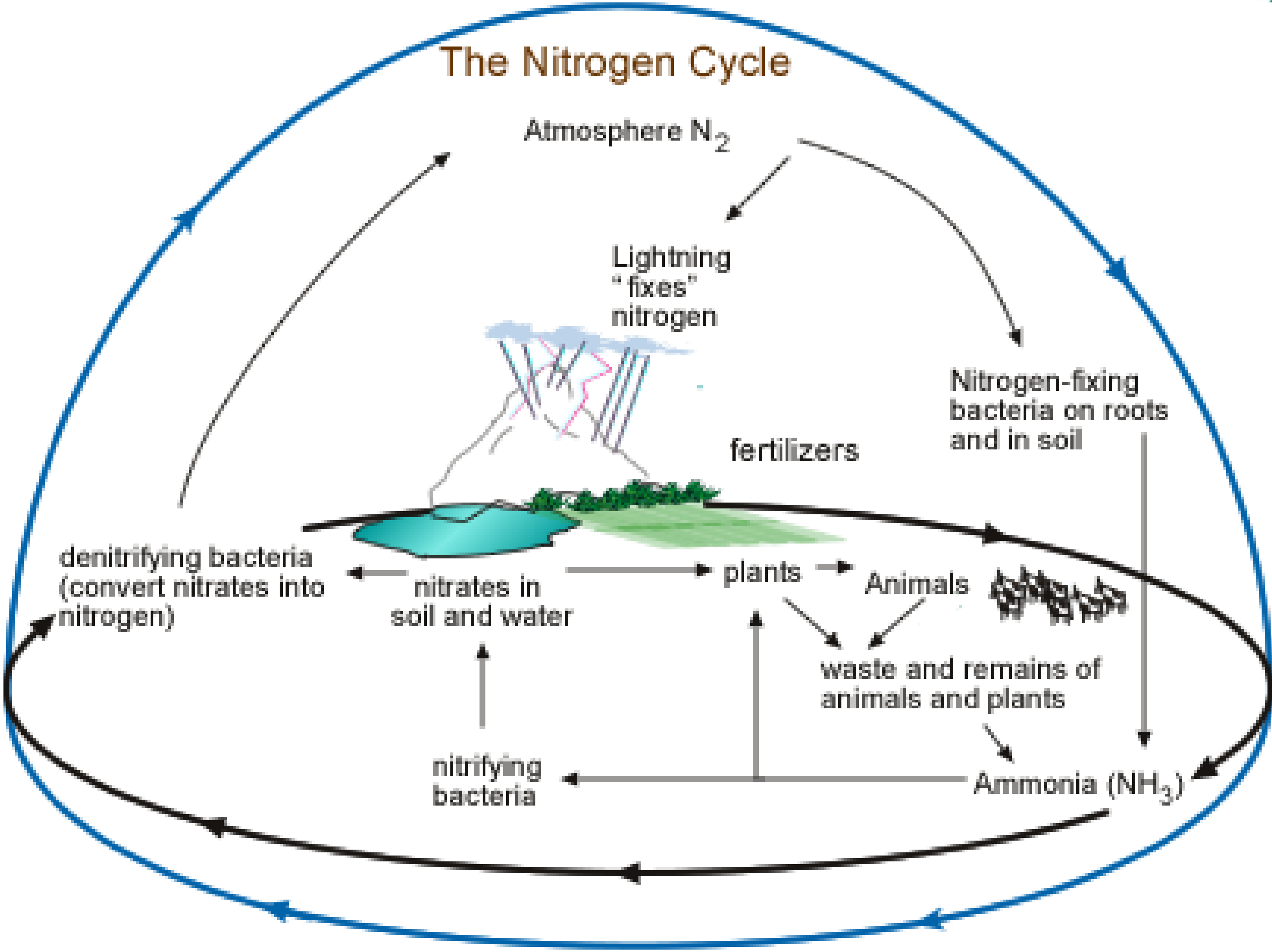


The biosphere as source and sink of trace gases

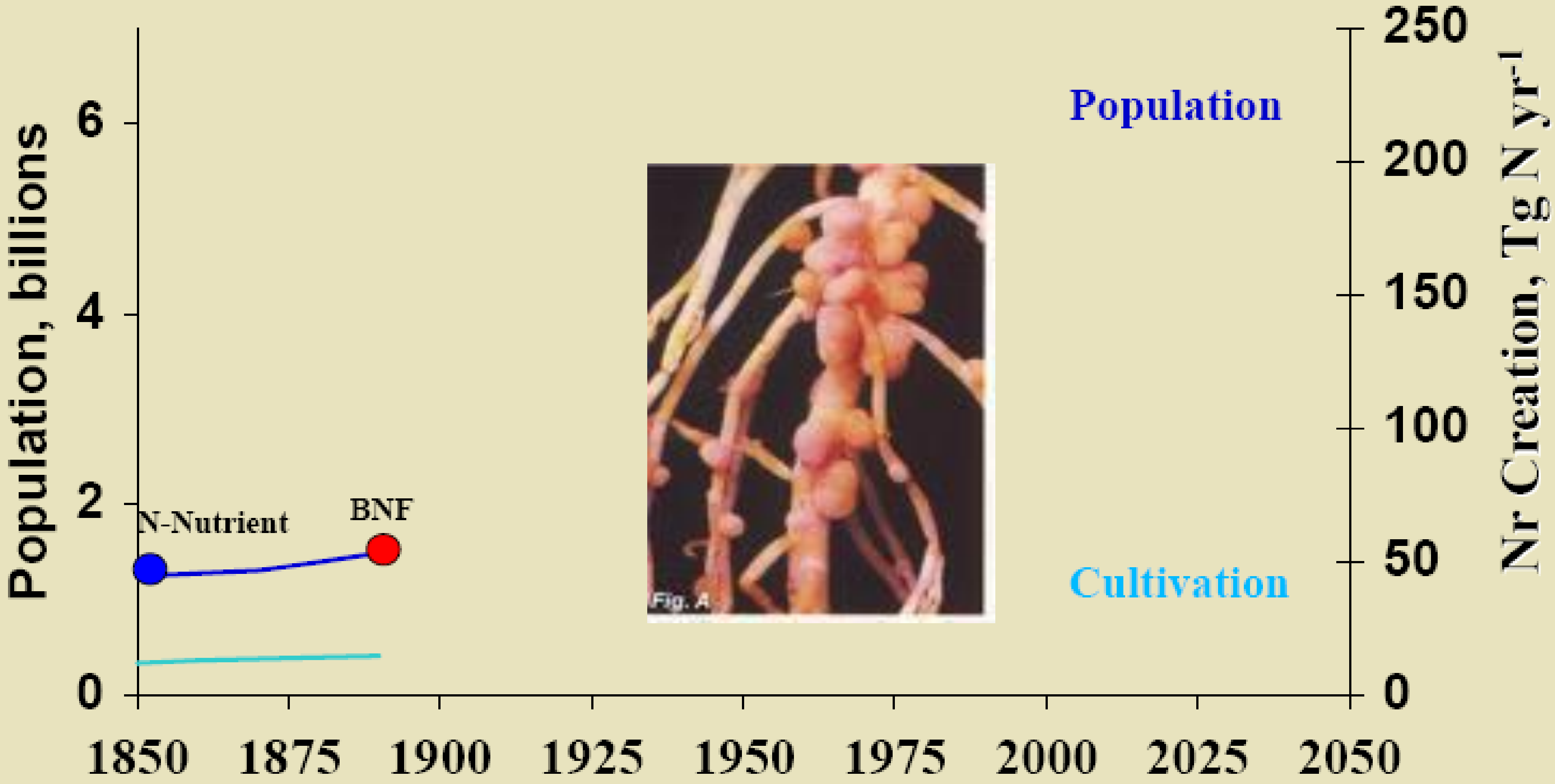


The Biosphere

- major source/ sink for trace substances (N_2O, CH_4, NO_x, CO_2, VOC)
- dynamic exchange with atmosphere
- effects chemical composition of the atmosphere
- and,thus, environmental conditions on earth (e.g. climate and air pollution)

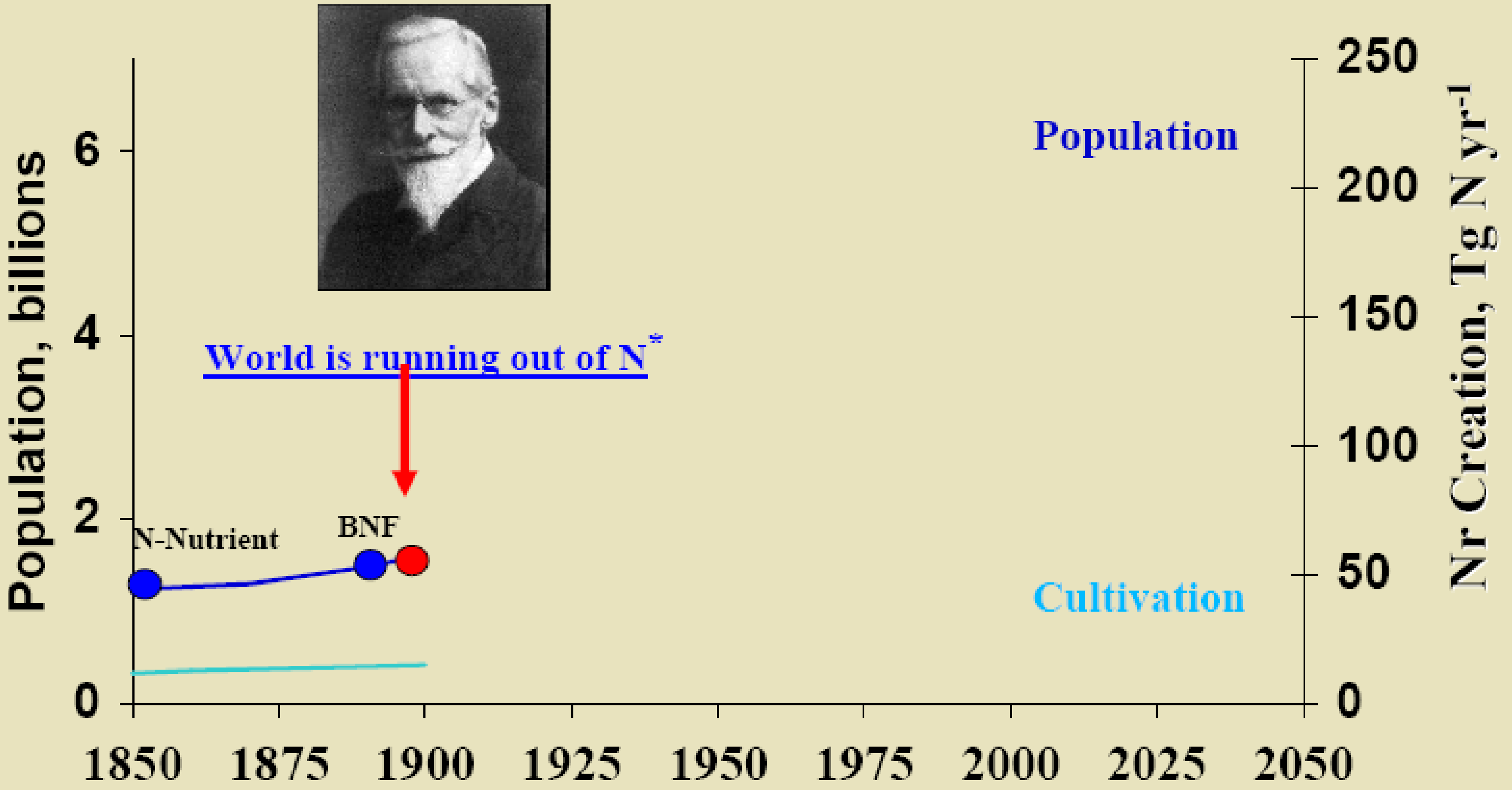

The Nitrogen Cycle
Atmosphere N2
Lightning
" fixes"
nitrogen
fertilizers
Nitrogen-fixing
bacteria on roots
and in soil
denitrifying bacteria
(convert nitrates into
nitrogen)
nitrates in
soil and water
plants
Animals
waste and remains of
animals and plants
nitrifying
bacteria
Ammonia (NH3)

Timeline of Global Reactive N Creation by Human Activity
1850 to 2000



Galloway et al., 2003

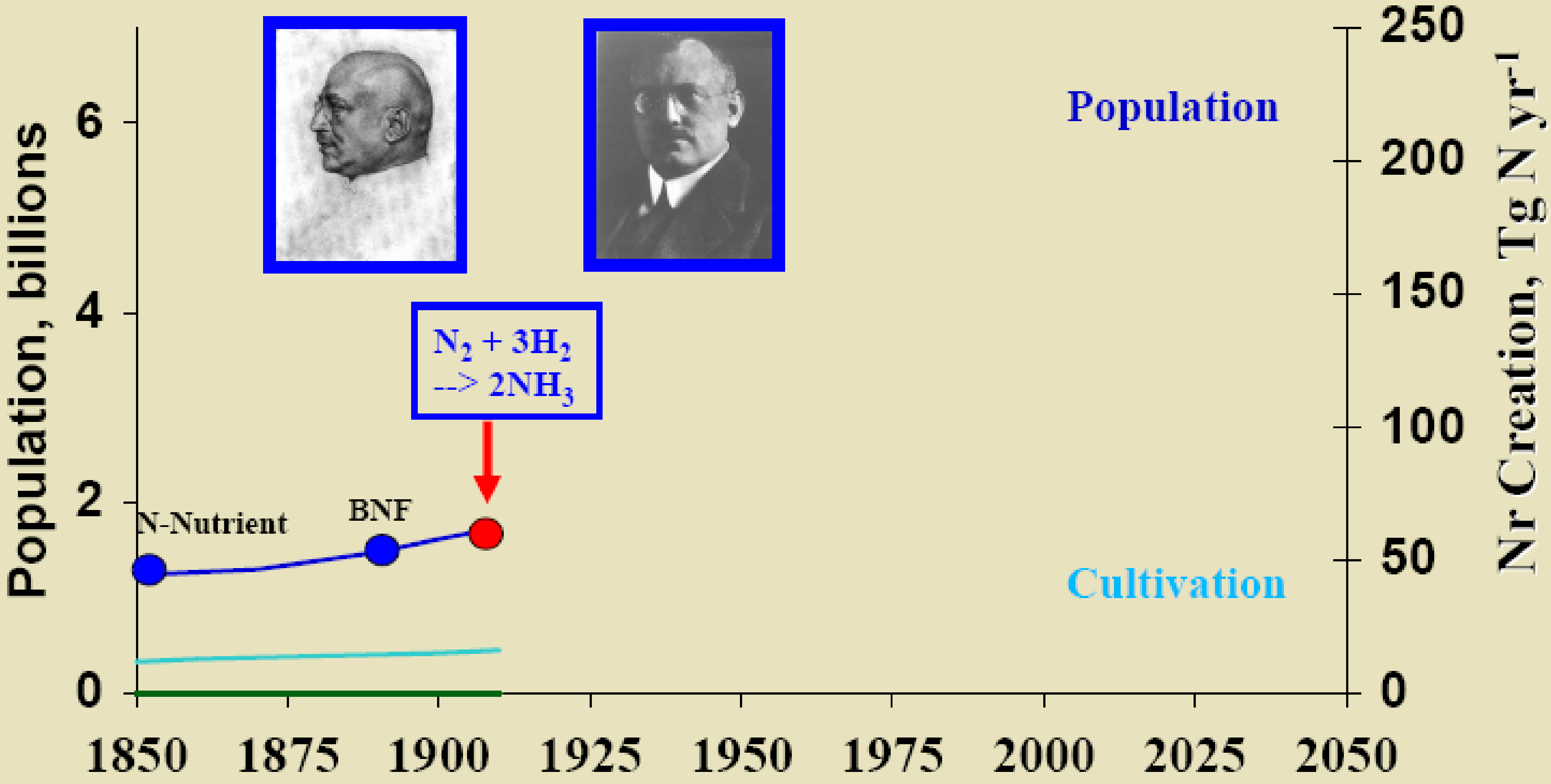
Timeline of Global Reactive N Creation by Human Activity 1850 to 2000



*1898, Sir William Crookes, president of the British Association for the Advancement of Science

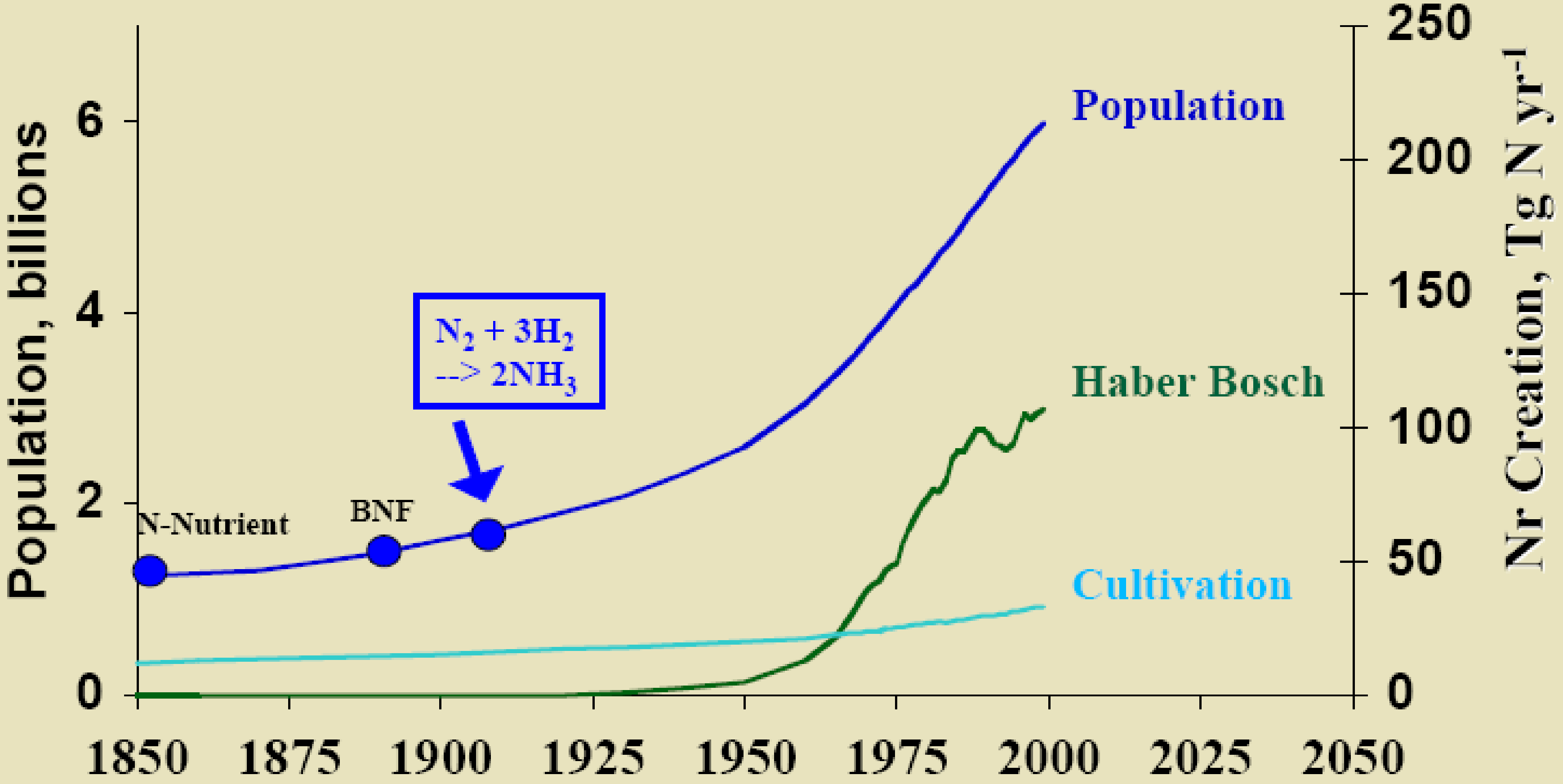
Galloway et al., 2003

Timeline of Global Reactive N Creation by Human Activity 1850 to 2000



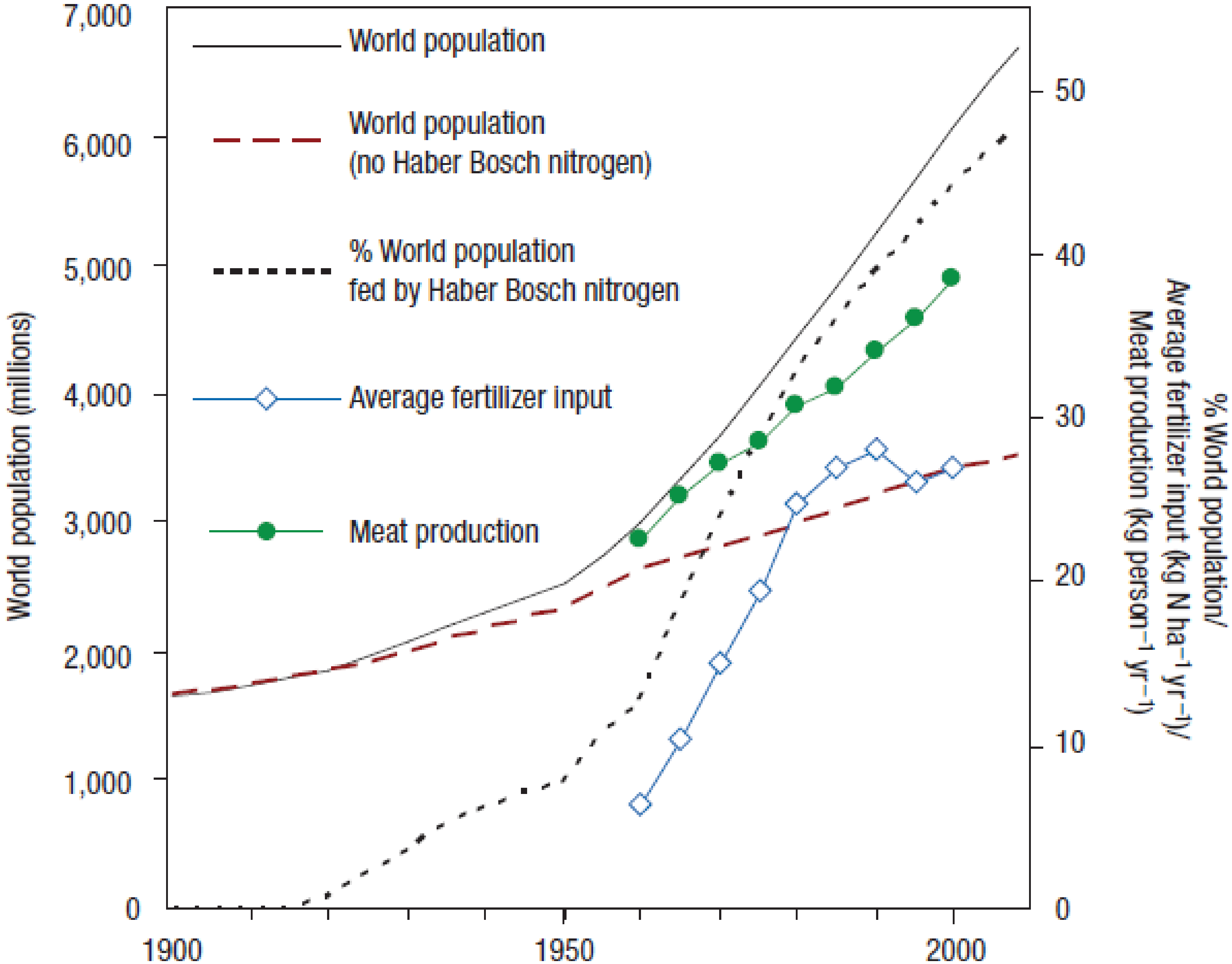
Galloway et al., 2003

Timeline of Global Reactive N Creation by Human Activity 1850 to 2000



Galloway et al., 2003

Nitrogen and global population increase



Erisman et al., 2008; Nature - Geosciences

The fate of nitrogen

N Fertilizer Produced

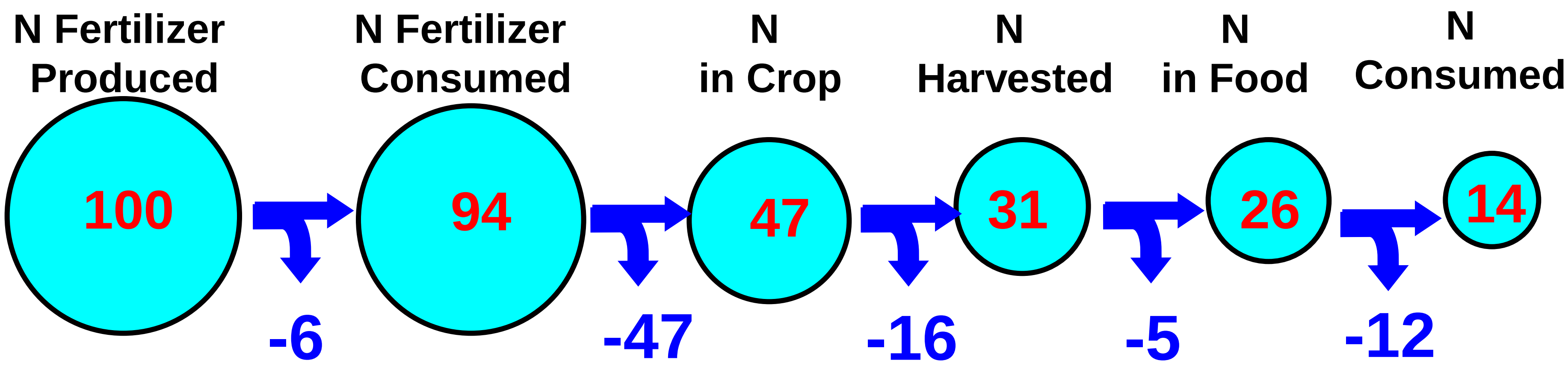
100

The fate of nitrogen

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

Galloway JN and Cowling EB. 2002

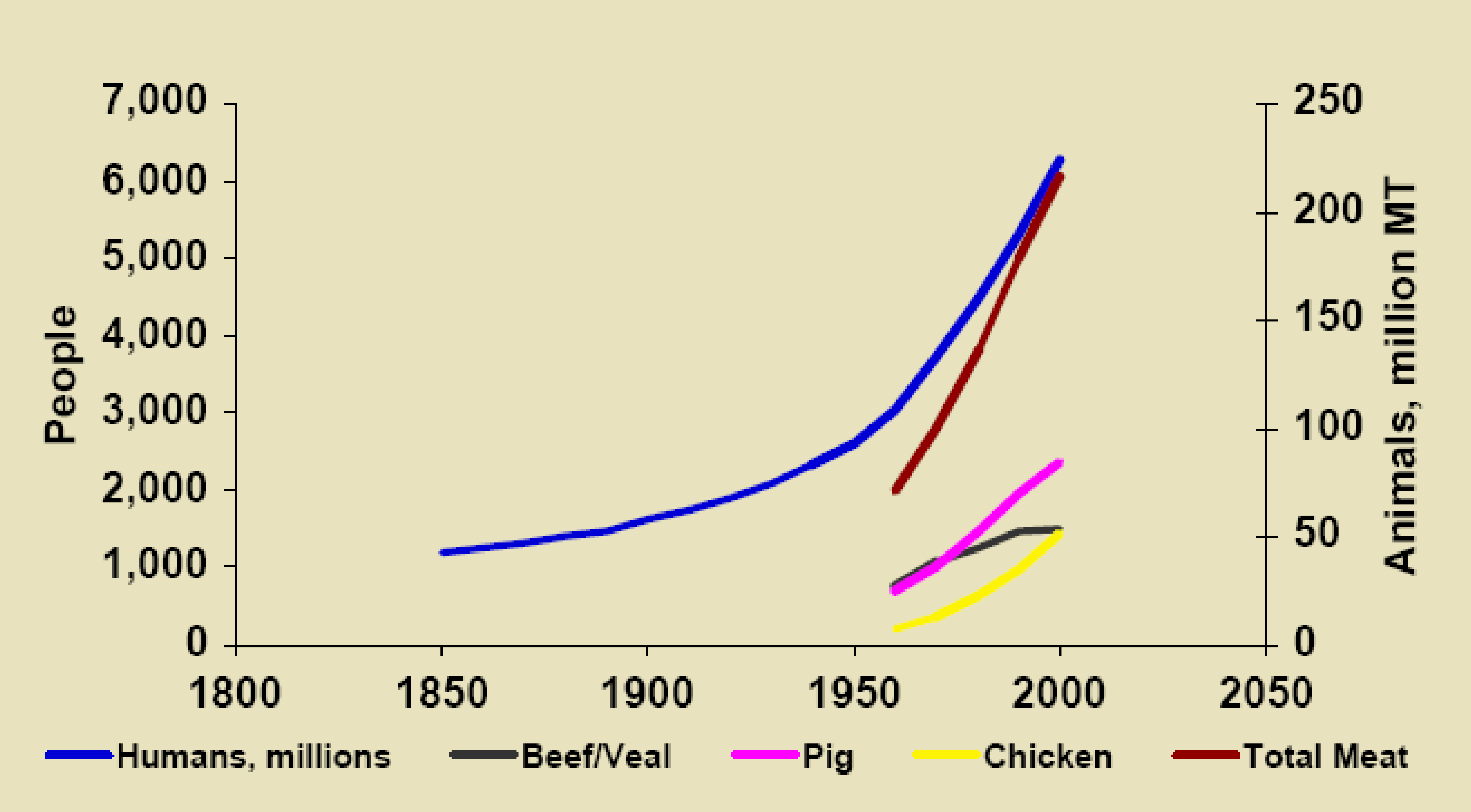
The fate of nitrogen



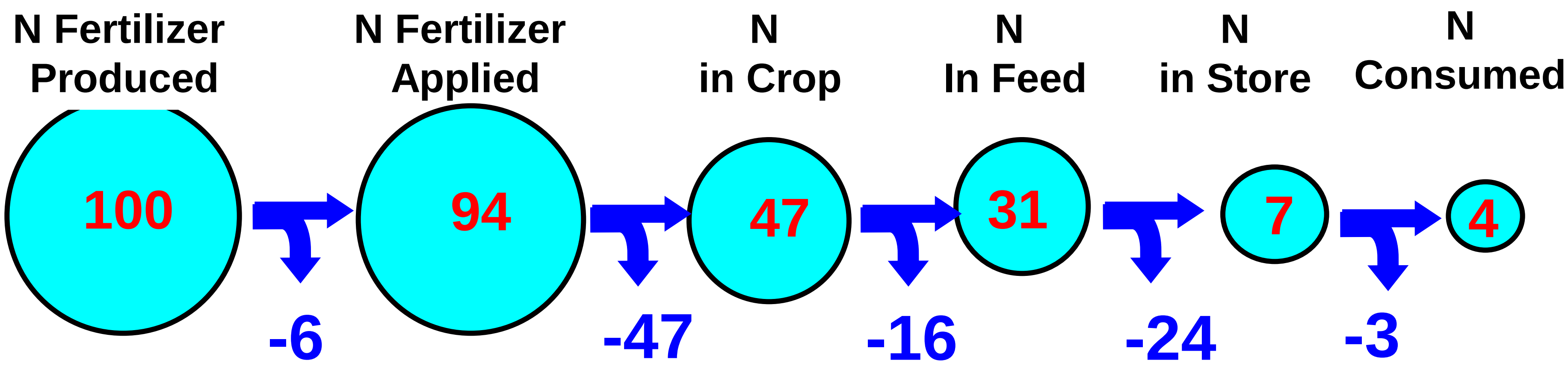
14% of the N produced in the Haber-Bosch process enters the human mouth……….if you are a vegetarian.

Galloway JN and Cowling EB. 2002

Global human population and meat production



The fate of nitrogen

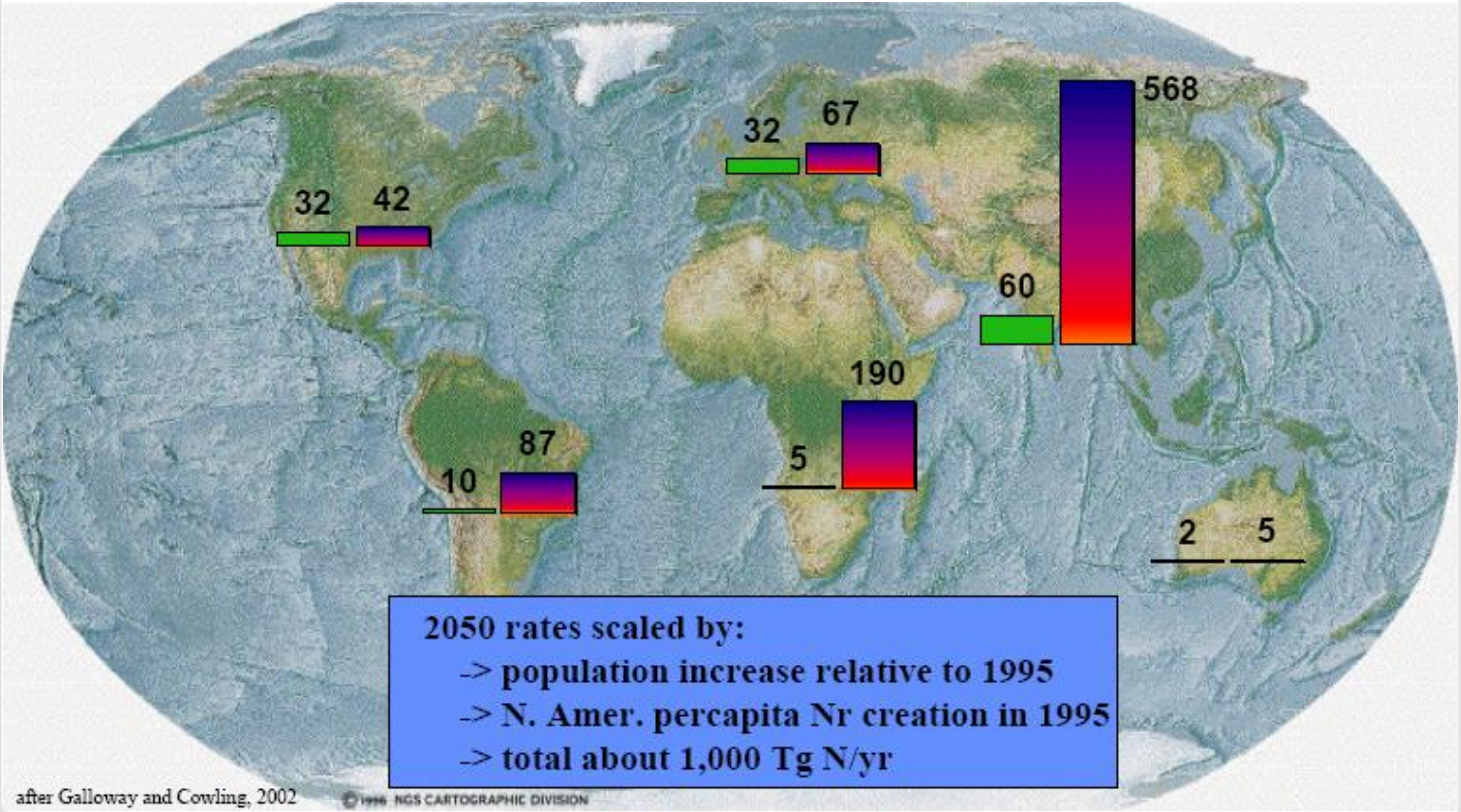


4% of the N produced in the Haber-Bosch process and used for animal production enters the human mouth.

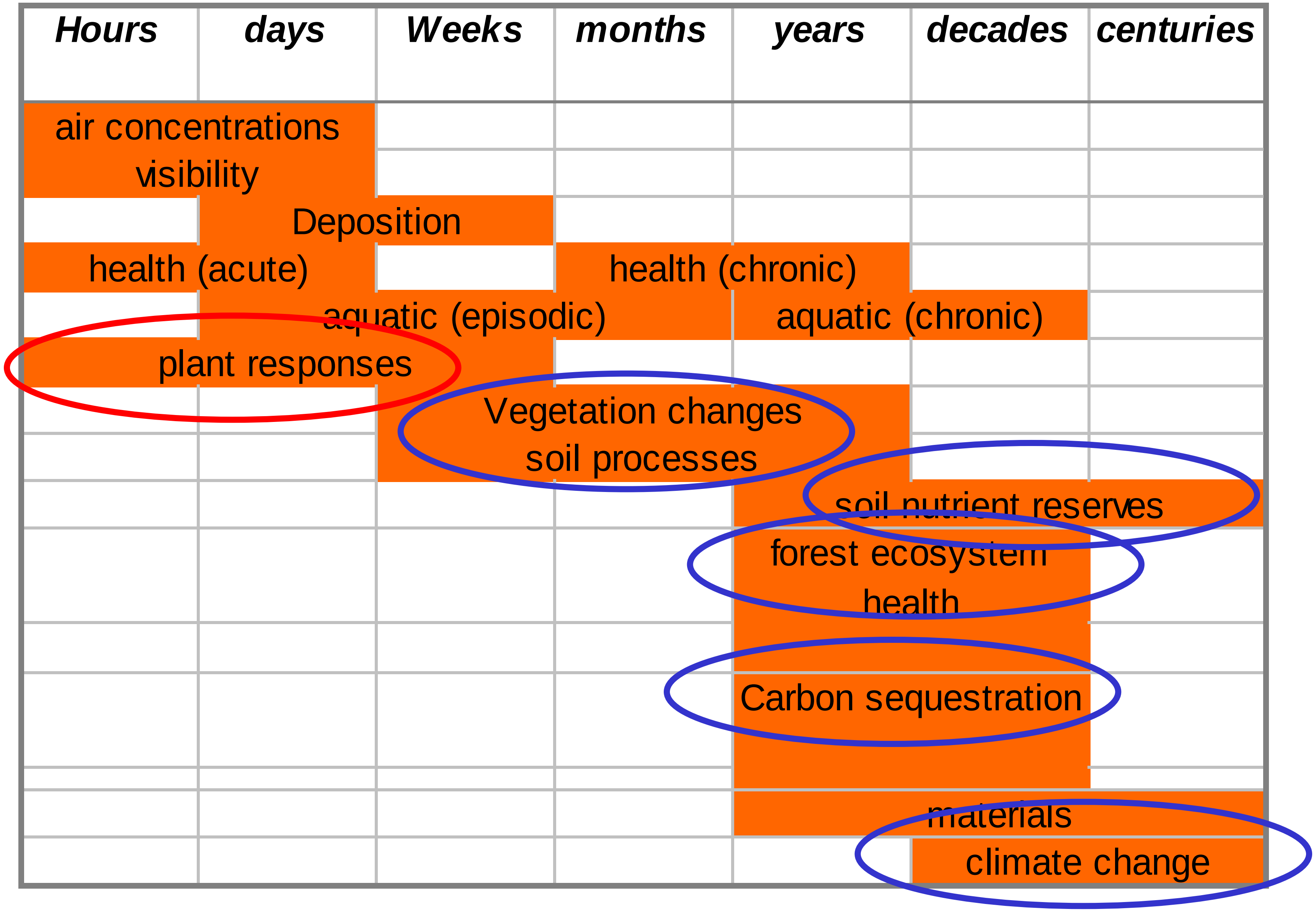
Galloway JN and Cowling EB. 2002

The global nitrogen cycle

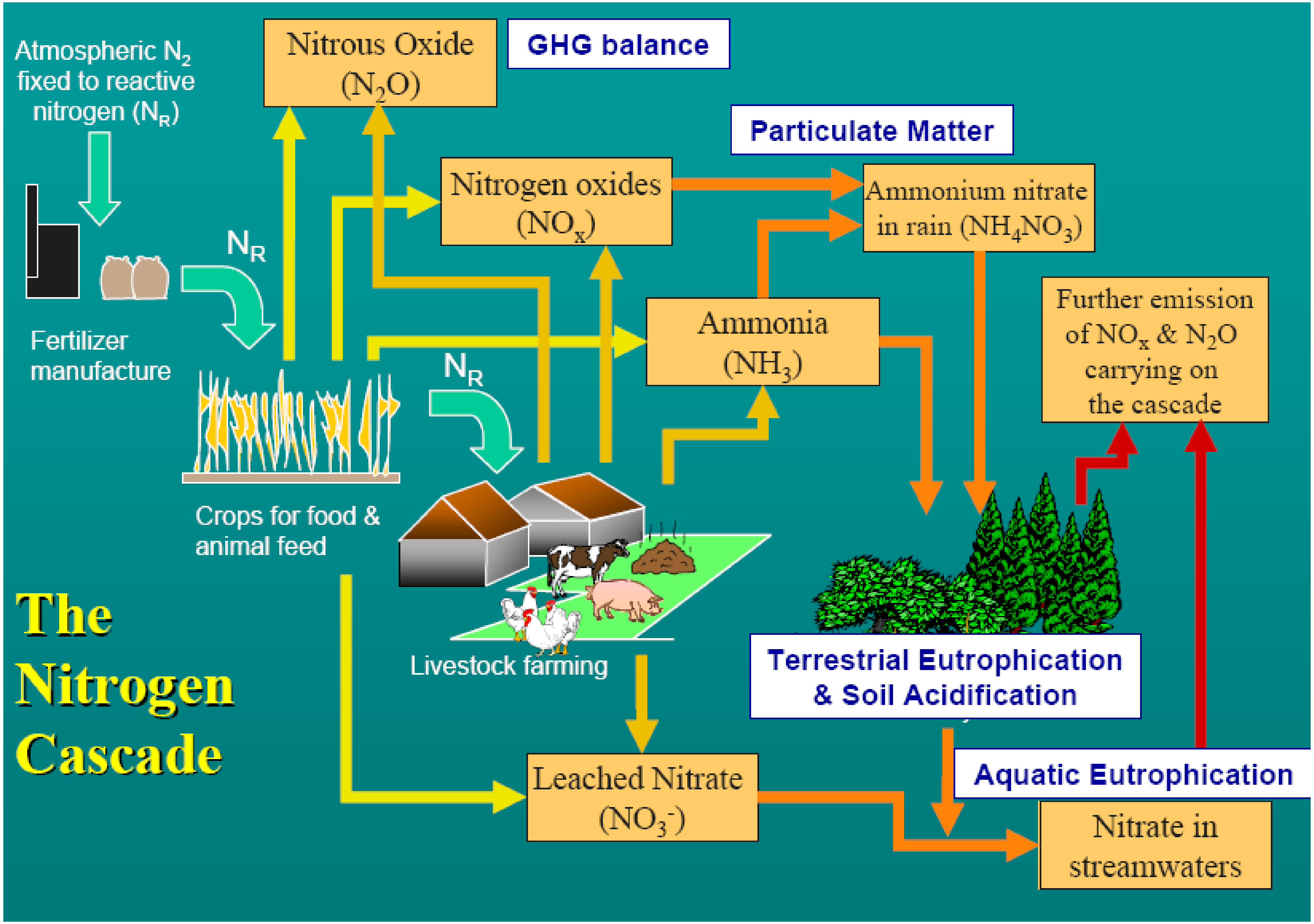
Nr creation 1995 (left) and 2050 (right) [Tg N yr^{-1}]



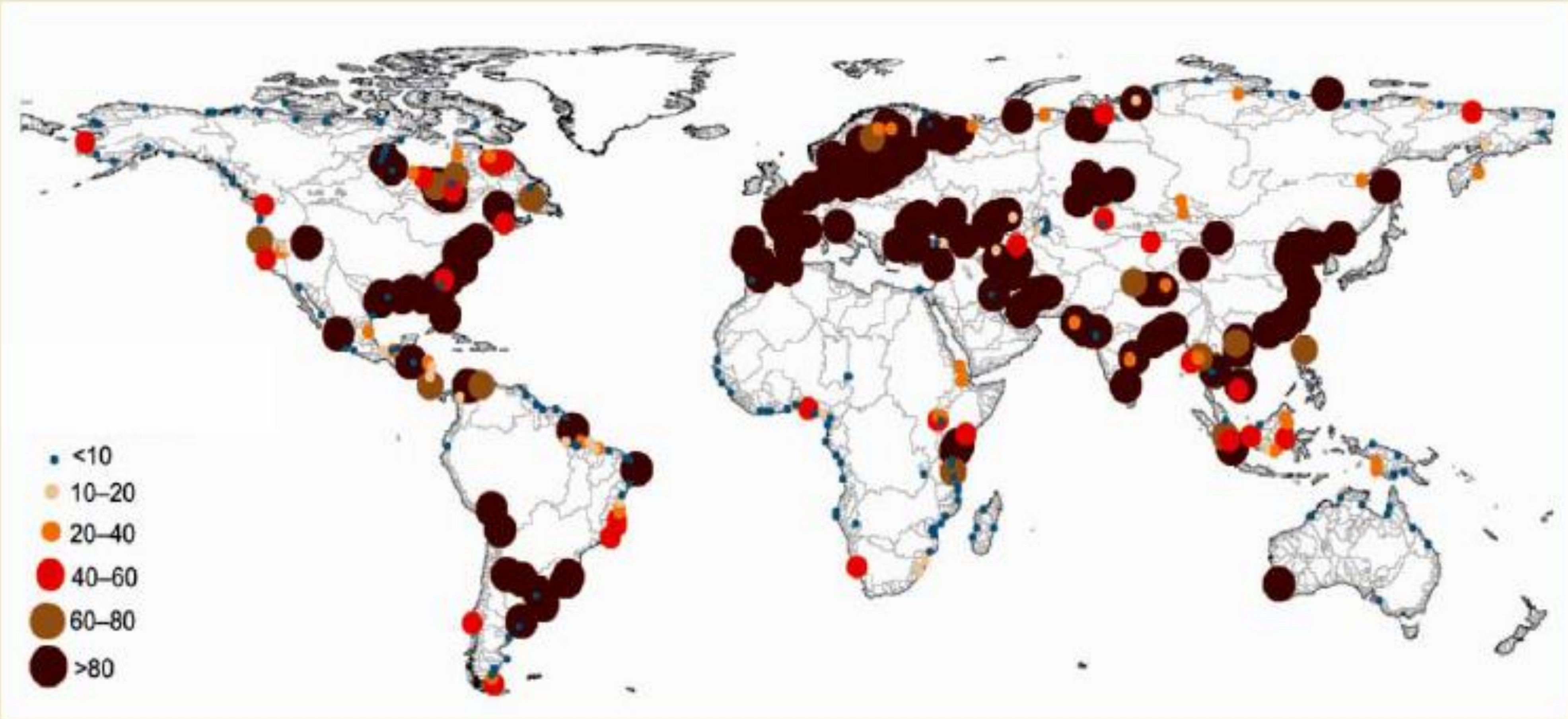
Ecological and social consequences of Nr



The Nr cascade



Increase in nitrogen flows in rivers

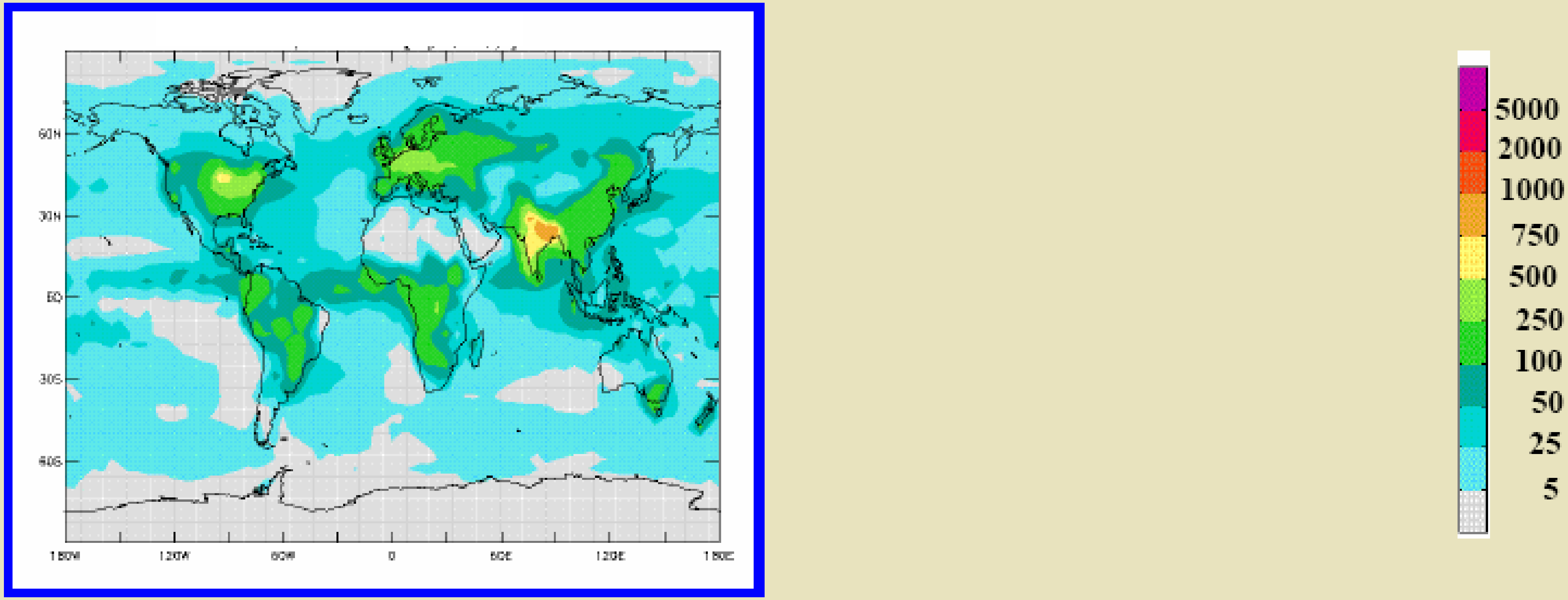


◆Most of the Nr created for food production, is released to the environment

◆About 25% is discharged to the coast via rivers

Source: Millennium Ecosystem Assessment

Nr deposition in 1860 and 1993 [mg m^{-2} yr^{-1}]

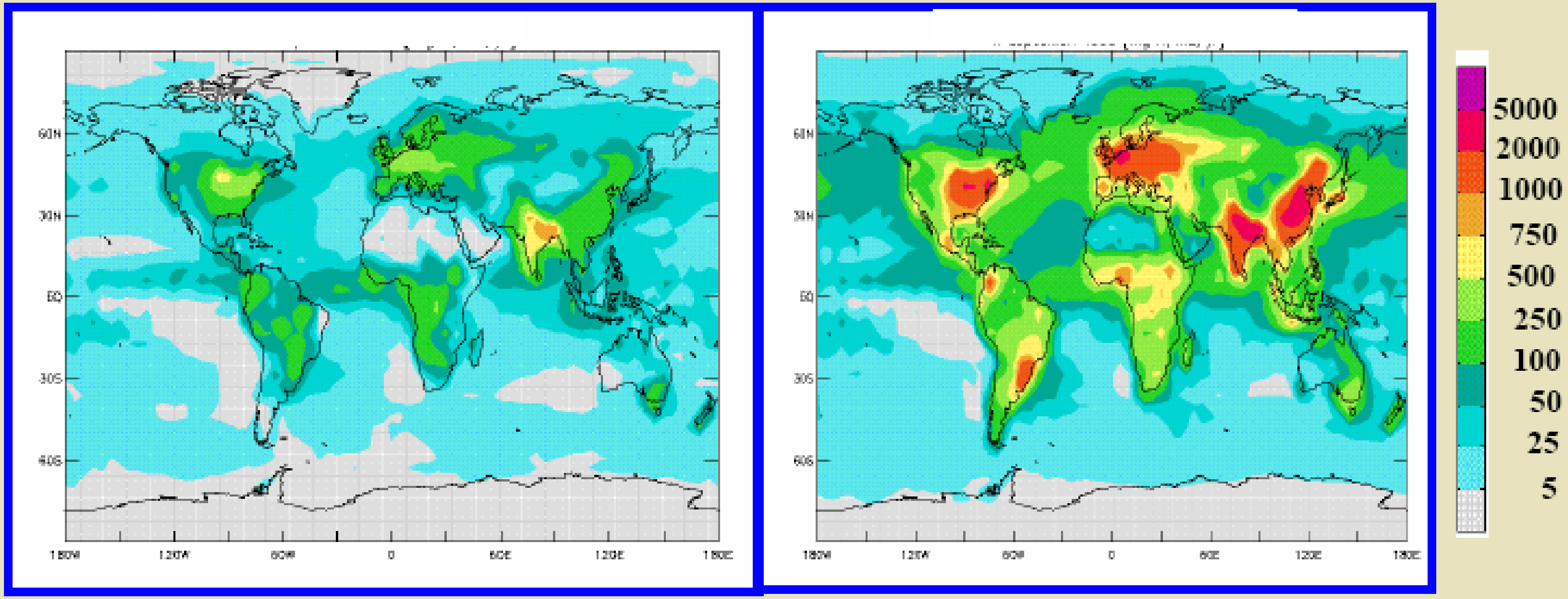


1860

- **Nitrogen is emitted as NOx to the atmosphere by fossil fuel combustion**
- **Nitrogen is emitted as NH_3 and NOx from food production.**
- **Once emitted, it is transported and deposited to ecosystems.**
- **In 1860, human activities had limited influence on N deposition.**

Galloway et al., 2003b

Nr deposition in 1860 and 1993 [mg m^{-2} yr^{-1}]



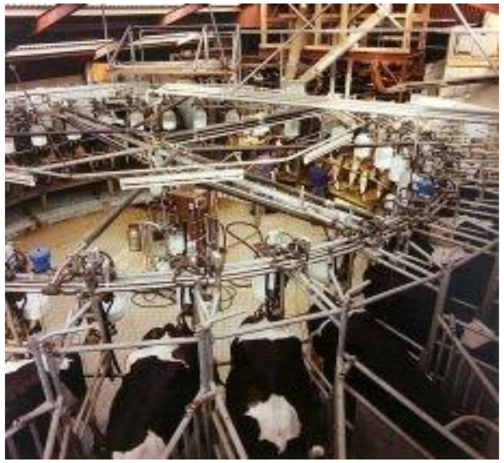
1860 1993

- Nitrogen is emitted as NOx to the atmosphere by fossil fuel combustion
- Nitrogen is emitted as NH_3 and NOx from food production.
- Once emitted, it is transported and deposited to ecosystems.
- In 1860, human activities had limited influence on N deposition.
- By 1993, the picture had changed.

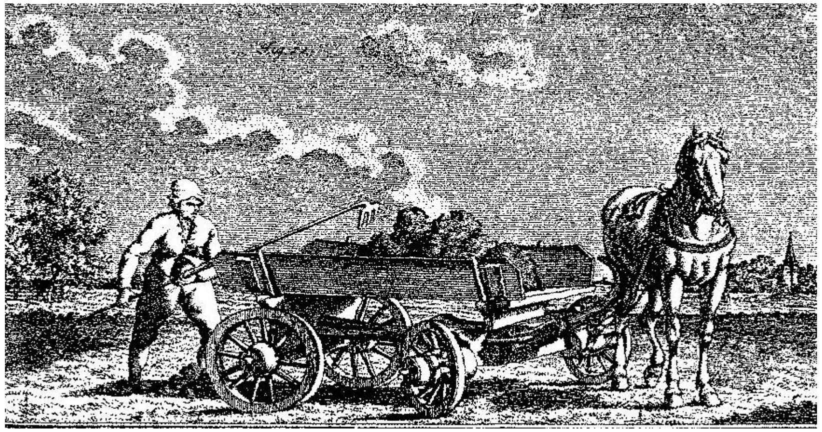
Galloway et al., 2003b

Historical development

Closed nutrient cycles



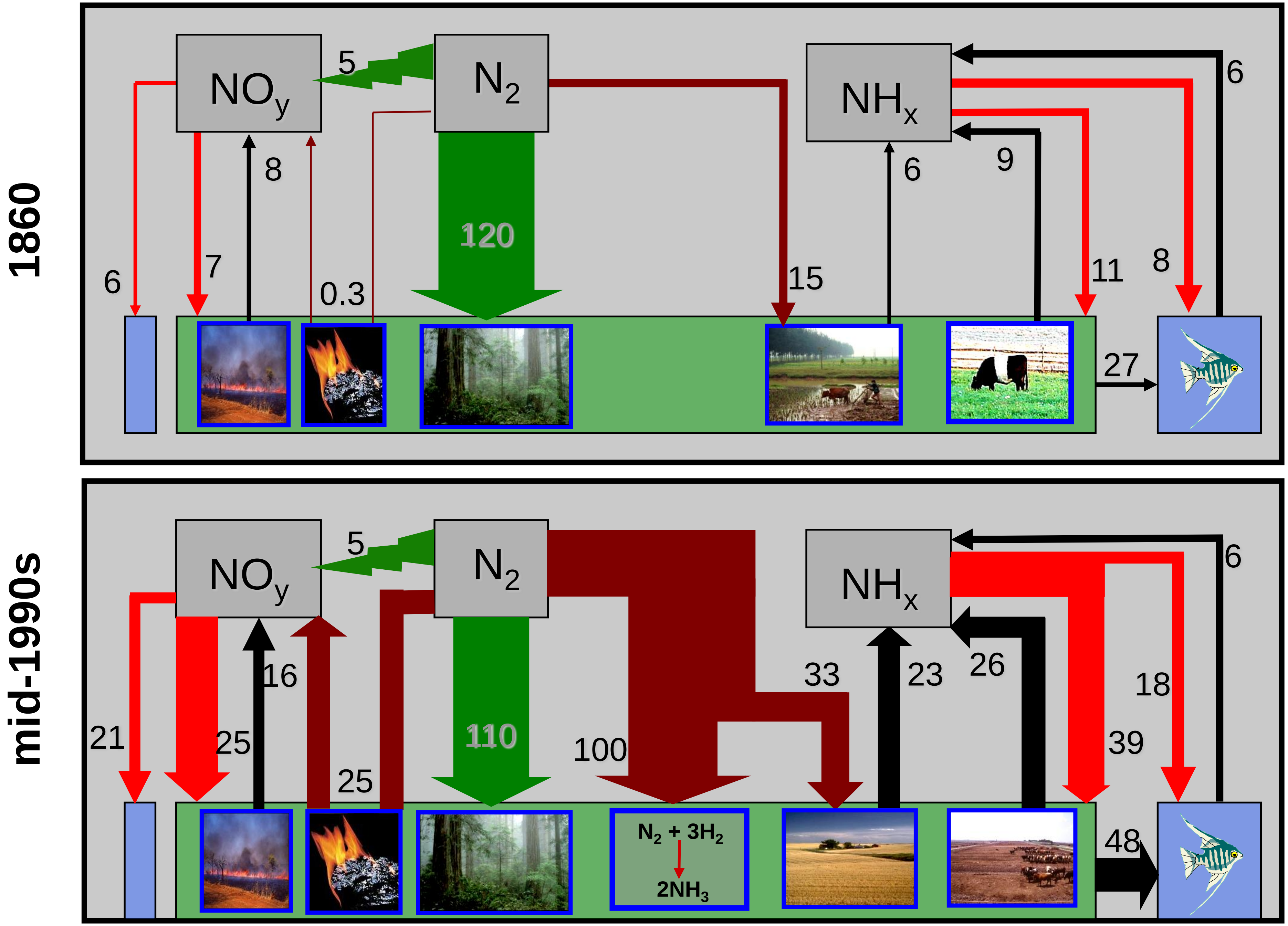
Intensive agriculture



Industrialisation

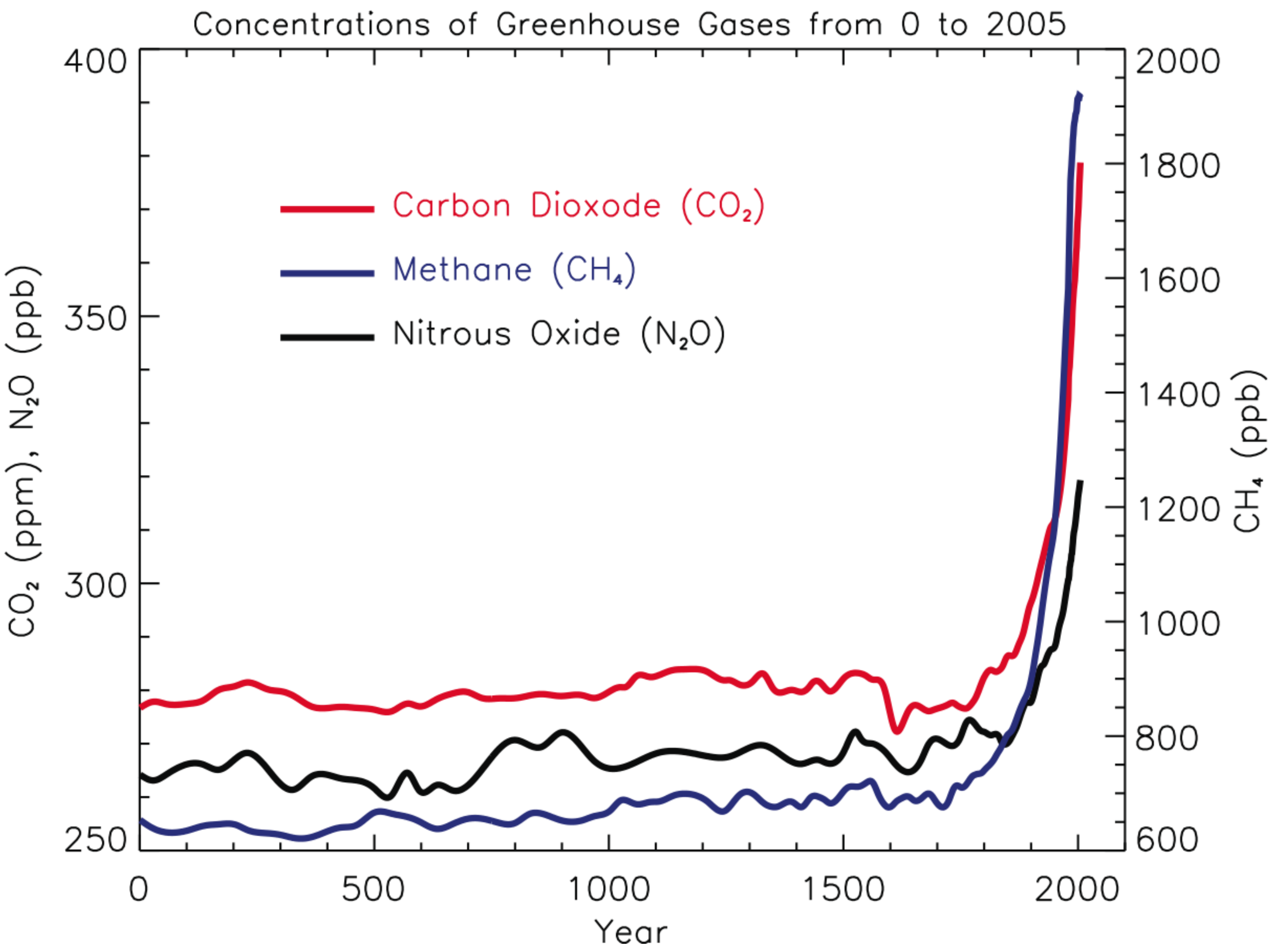
Man labor

The Global Nitrogen Budget in 1860 and mid-1990s, TgN/yr



Galloway et al., 2003b

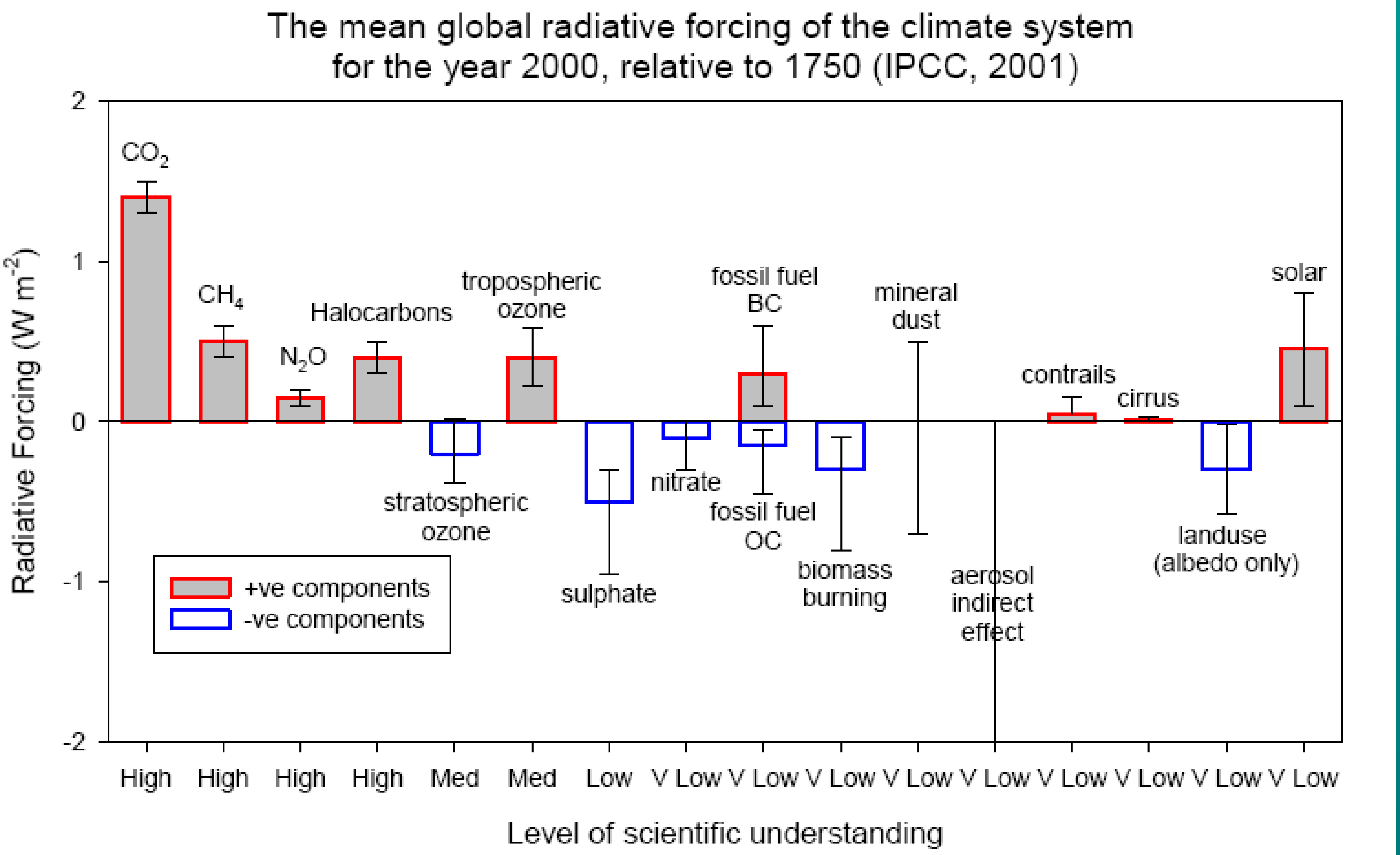
N_2O



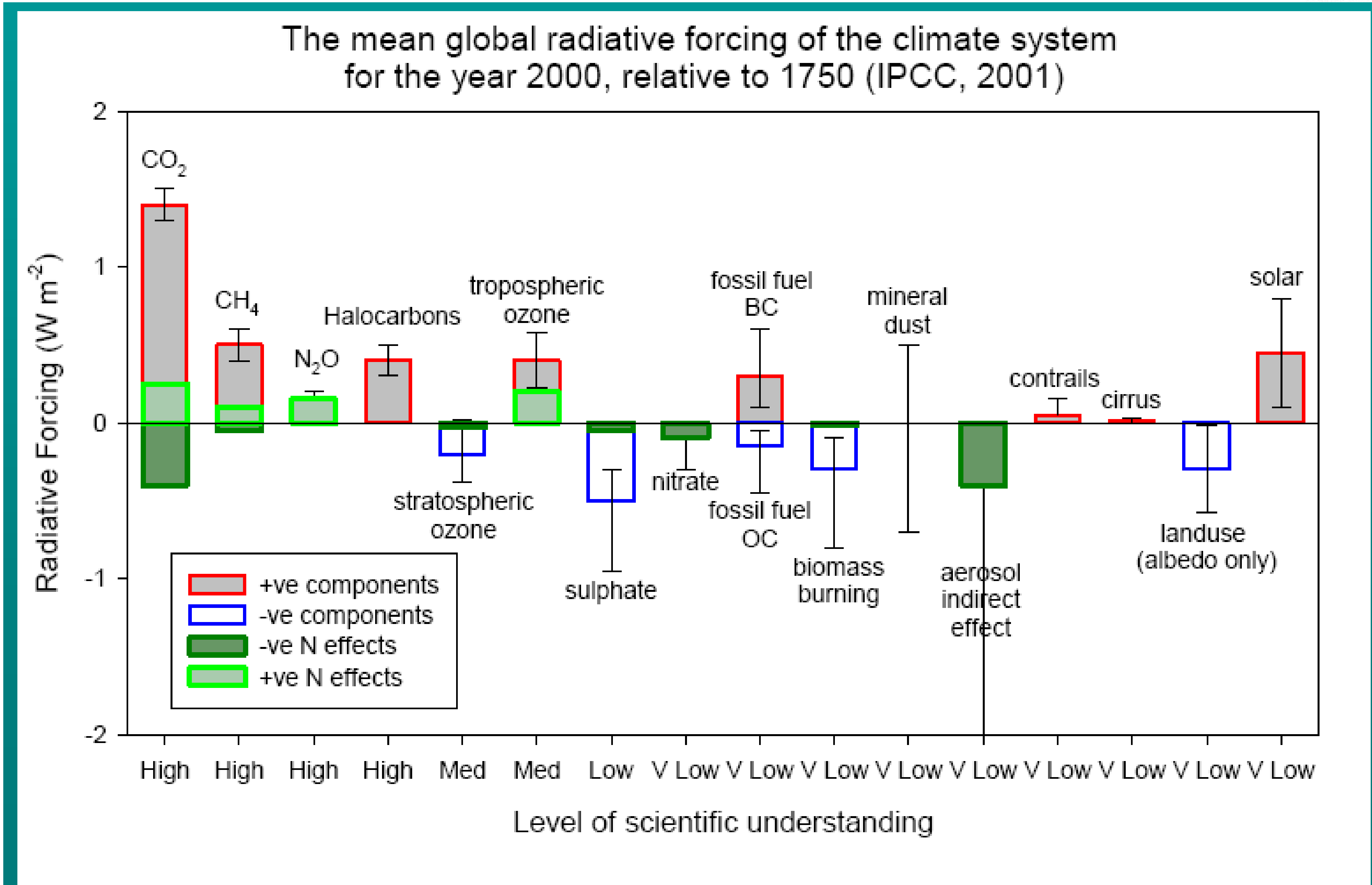
IPCC 2007

Industrial Designation or Common Name (years)	Chemical Formula	Lifetime (years)	Radiative Efficiency ($W\ m^{-2}\ ppb^{-1}$)	Global Warming Potential for Given Time Horizon: SAR‡ (100-yr)	20-yr	100-yr	500-yr
Carbon dioxide	CO_2	See below[a]	[b]1.4×10^{-5}	1	1	1	1
Methane[c]	CH_4	12[c]	3.7×10^{-4}	21	72	25	7.6
Nitrous oxide	N_2O	114	3.03×10^{-3}	310	289	298	153

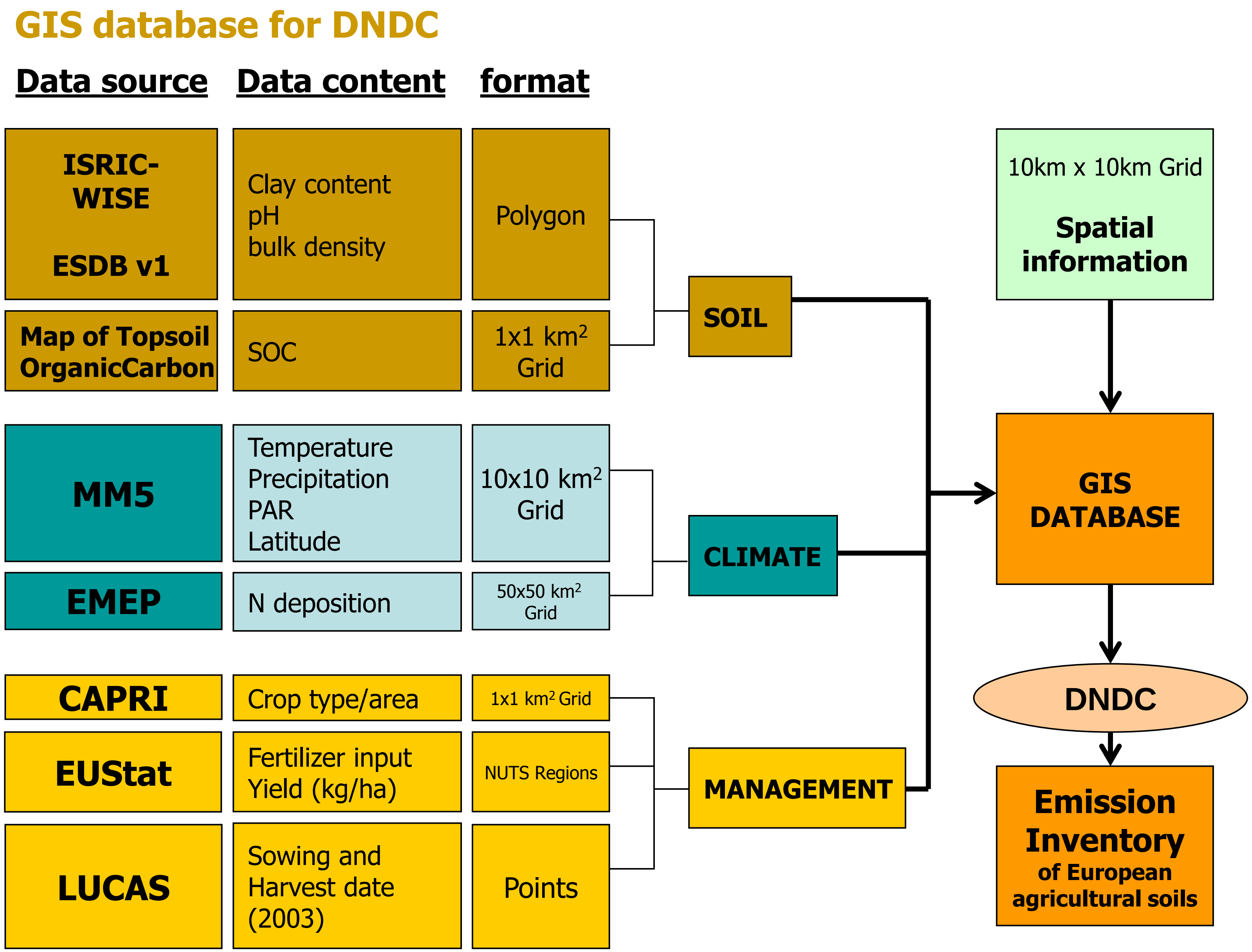
The effect of N on the GHG balance



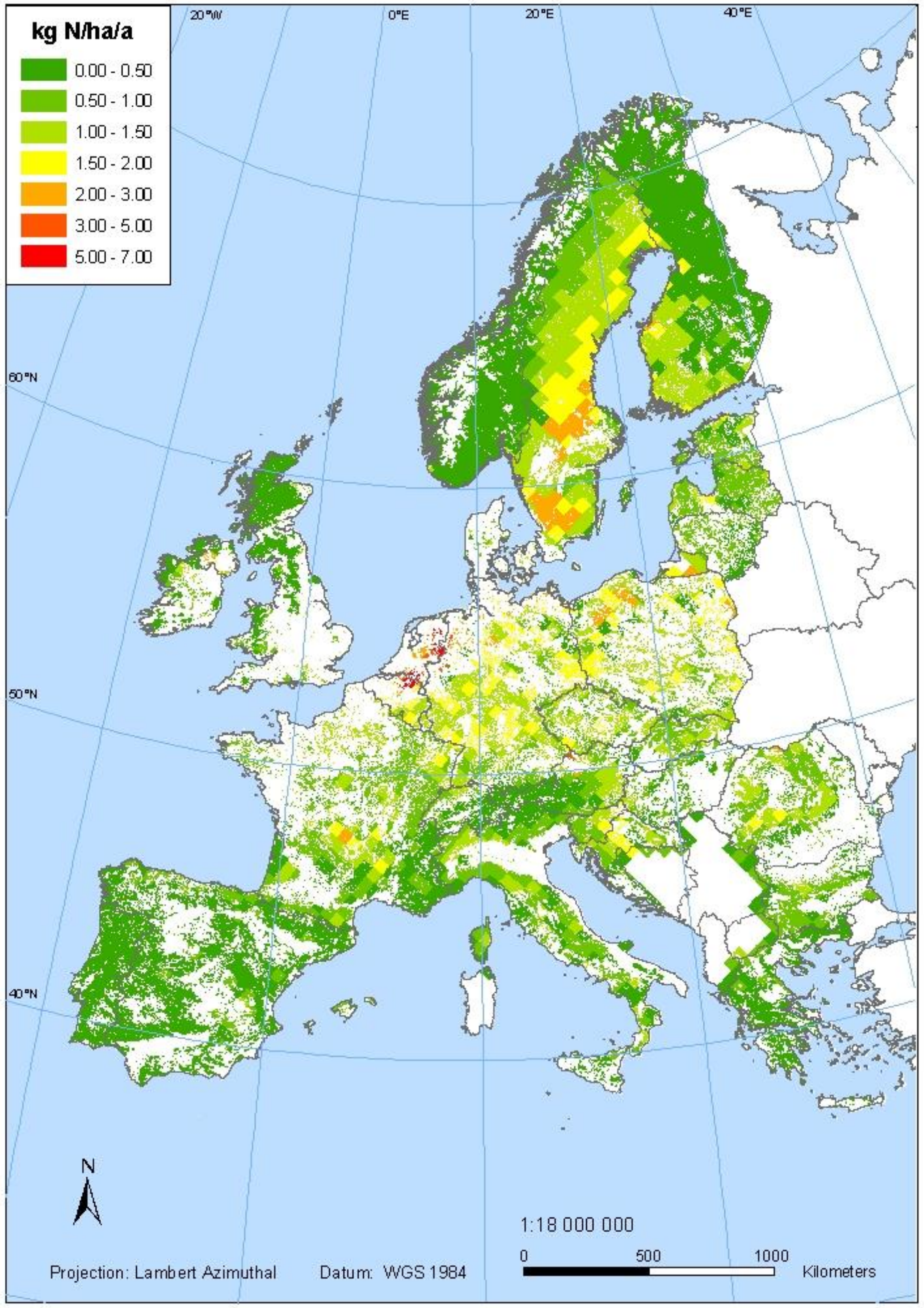
The effect of N on the GHG balance



GIS coupling for Inventories



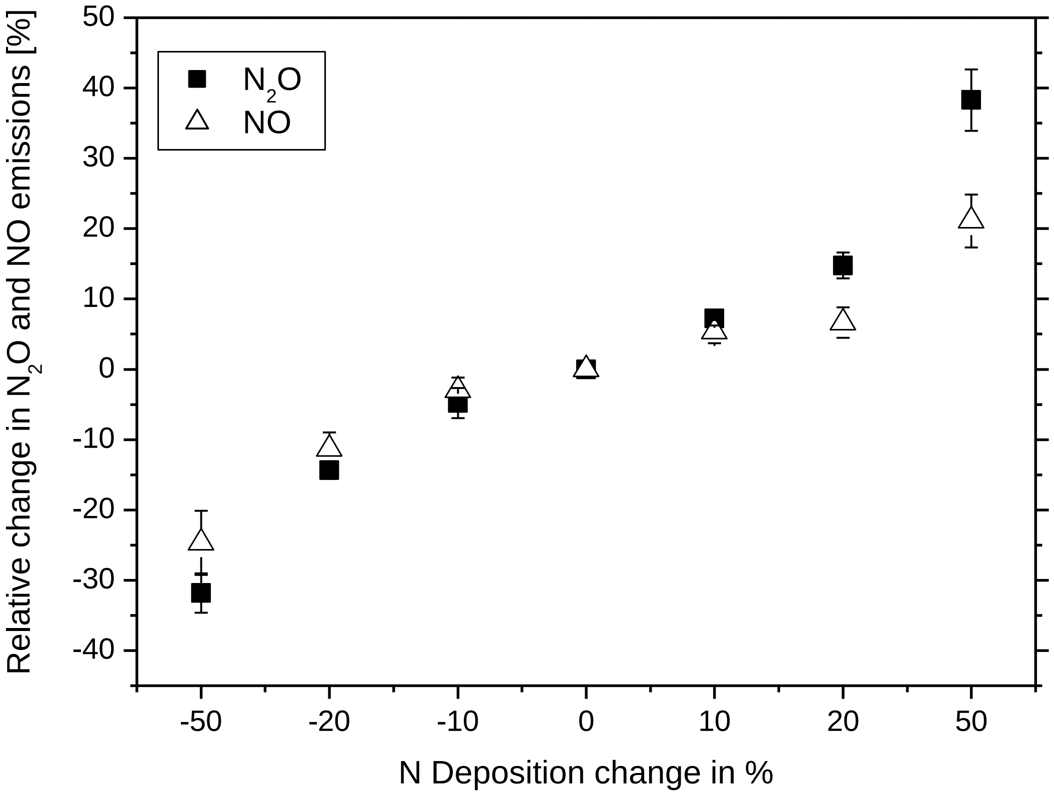
Inventorying soil N trace gas fluxes and identifying feedbacks



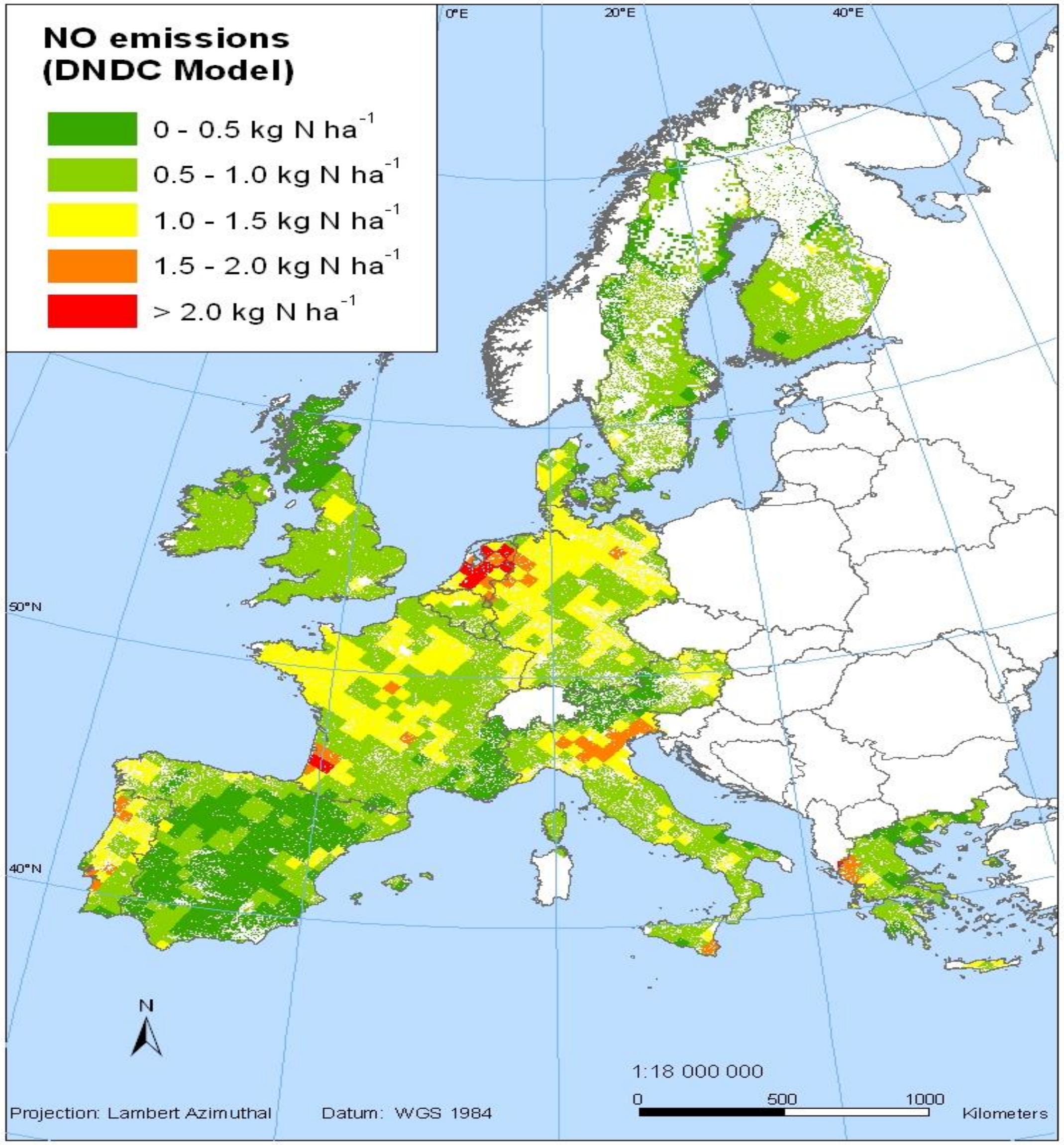
Kesik et al., 2006; Biogeosciences

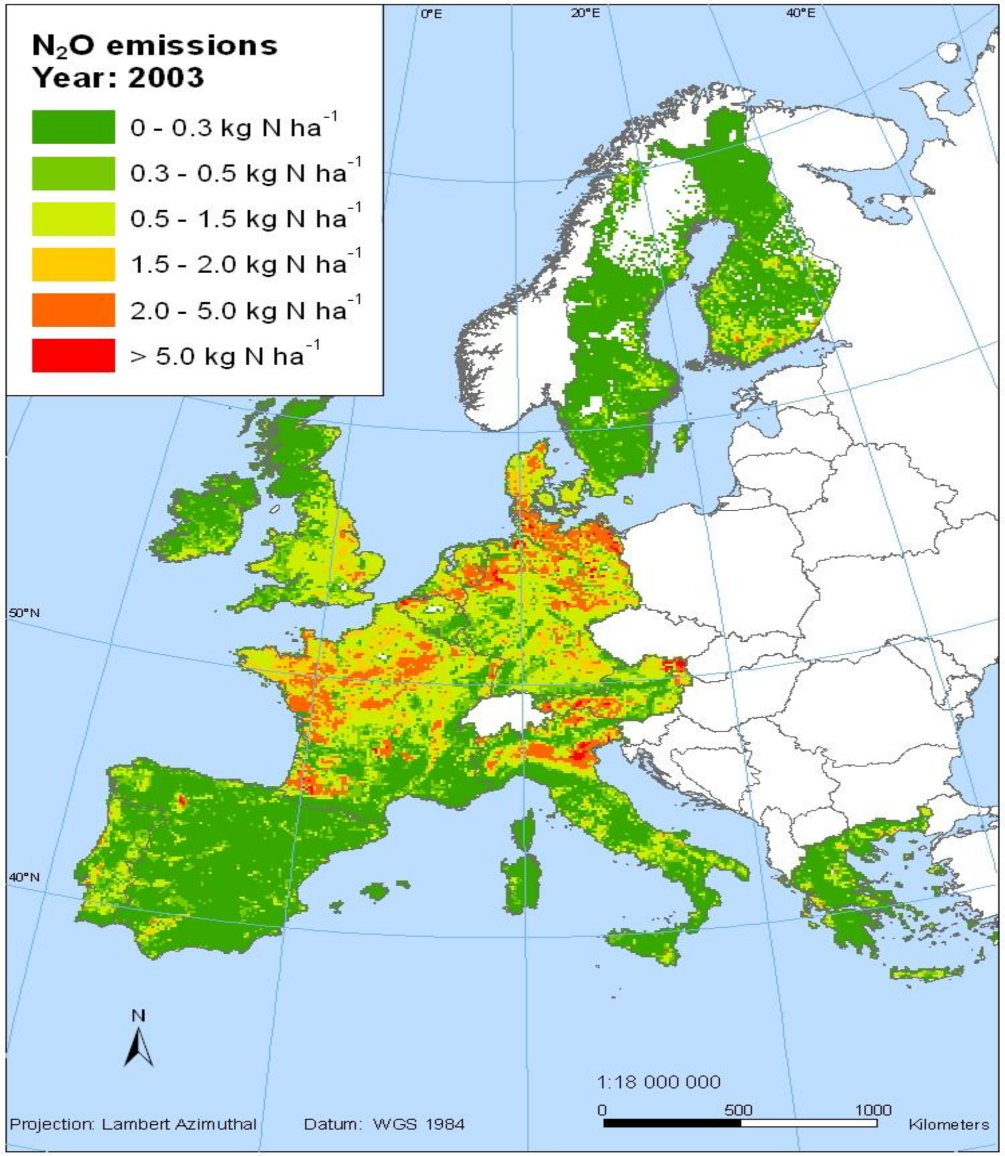
NO Emissions	Minimum Scenario kt N a^{-1}	Average Scenario kt N a^{-1}	Maximum Scenario kt N a^{-1}
1990	45	98	248
1995	38	85	220
2000	45	99	254

Simulated forest area of Europe: 1 410 477km²



Agricultural soils – NO & N_2O emissions

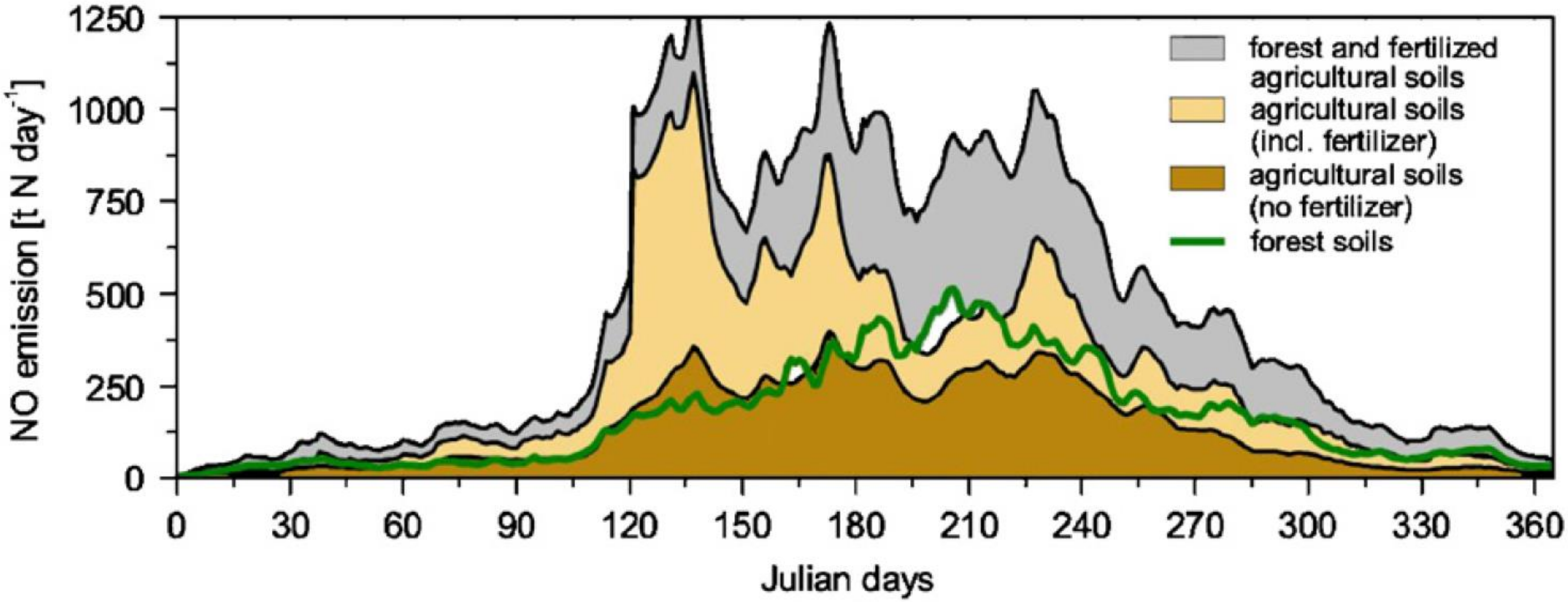




Butterbach-Bahl et al., 2008; Atm. Environm.

Soil sources versus industrial sources

Soil NO_x emissions are contributing in average for entire Europe up to 10% to the tropospheric NO_x burden



Butterbach-Bahl et al., 2009; Atm. Environm.

NitroEurope IP

Summary

- Human activities have perturbed the global nitrogen cycling
  - Acceleration by a factor of approx. 2 (C <10%)
- Large scale environmental impacts, e.g.
  - eutrophication
  - Biosphere-atmosphere exchange of GHG‘s
- Long-term effects and biosphere feedbacks to climate change unknown
- Increase in N use efficiency urgently needed