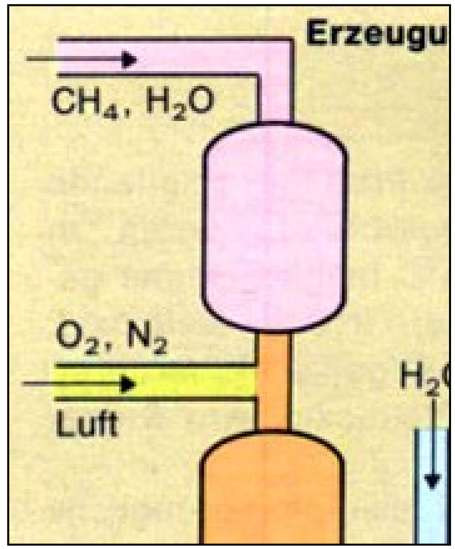
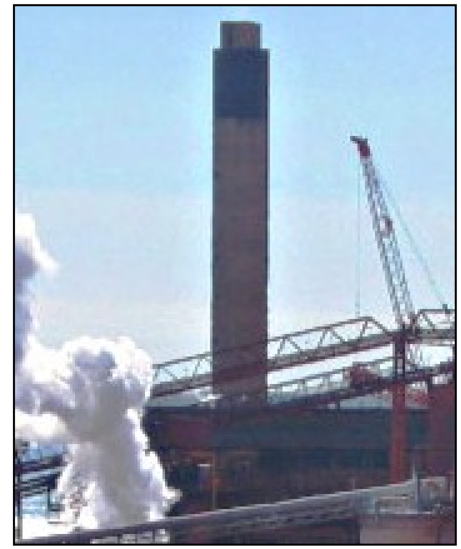
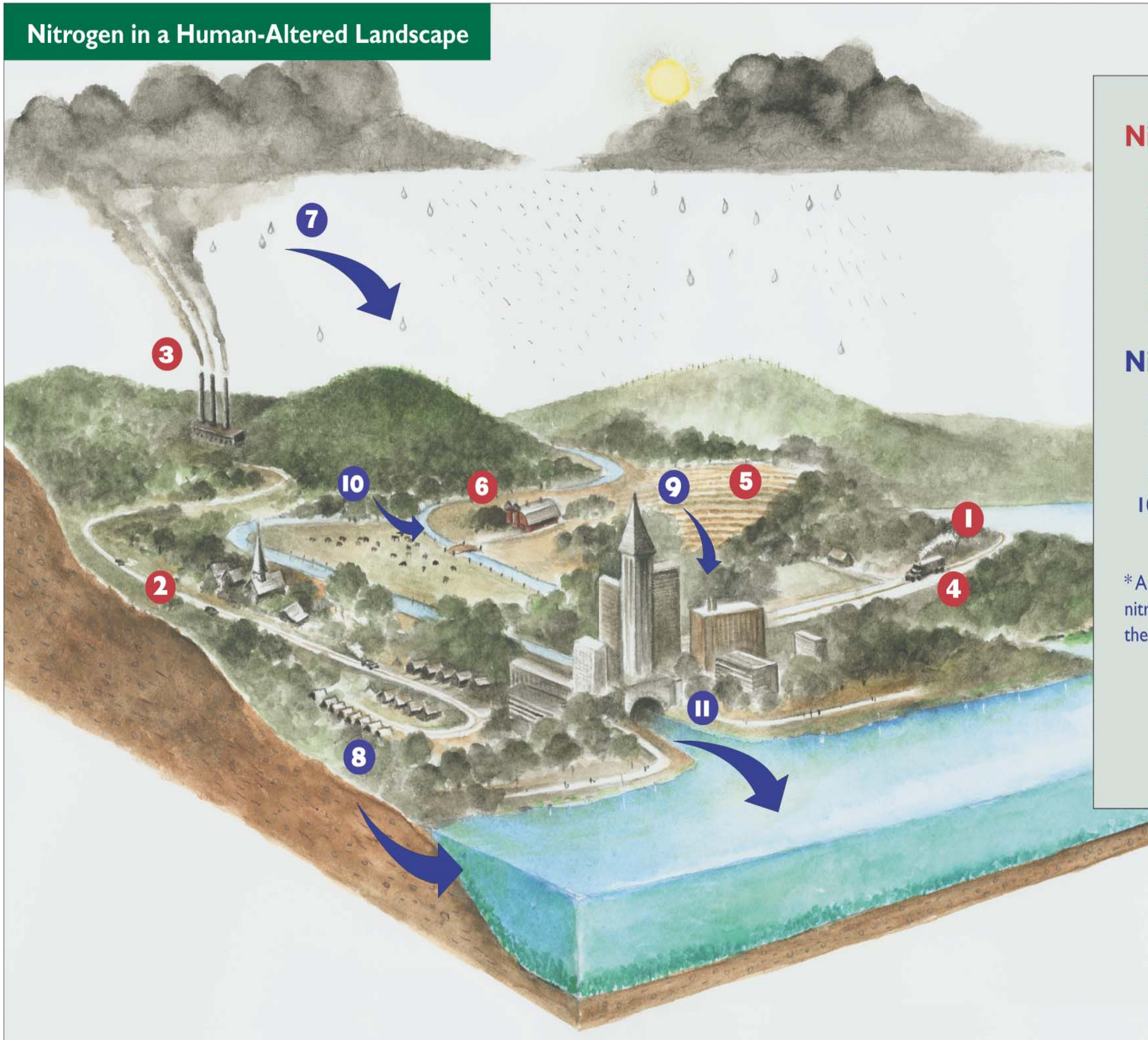
Management approaches for nitrogen emissions





Julian Aherne

TRENT UNIVERSITY



Nitrogen Sources:

1. Imported food and feed
2. Vehicle emissions
3. Powerplant emissions
4. Fertilizer imports
5. Fixation in croplands
6. Agricultural emissions

Nitrogen Fluxes:*

7. Atmospheric deposition
8. Wastewater from septic tanks and treatment plants
9. Agricultural runoff
10. Forest runoff

Urban runoff

*A flux is the movement of nitrogen from one component of the ecosystem to another.

source: www.hubbardbrook.org/hbrf

Management [science-based] approaches for [atmospheric] nitrogen emissions

Key questions. what are the:

Issues identified with nitrogen emissions in other jurisdictions?

Management approaches used: successes and failures?

Management approaches with respect to both emissions management and effects management?

How are these relevant to the AB situation?

Issues identified with nitrogen emissions in other jurisdictions?

Forest Ecology and Management 101 (1998)

Reactive nitrogen (Nr)

Ambio 31:2 (2002)

The nitrogen "cascade'

BioScience 53:4 (2003)

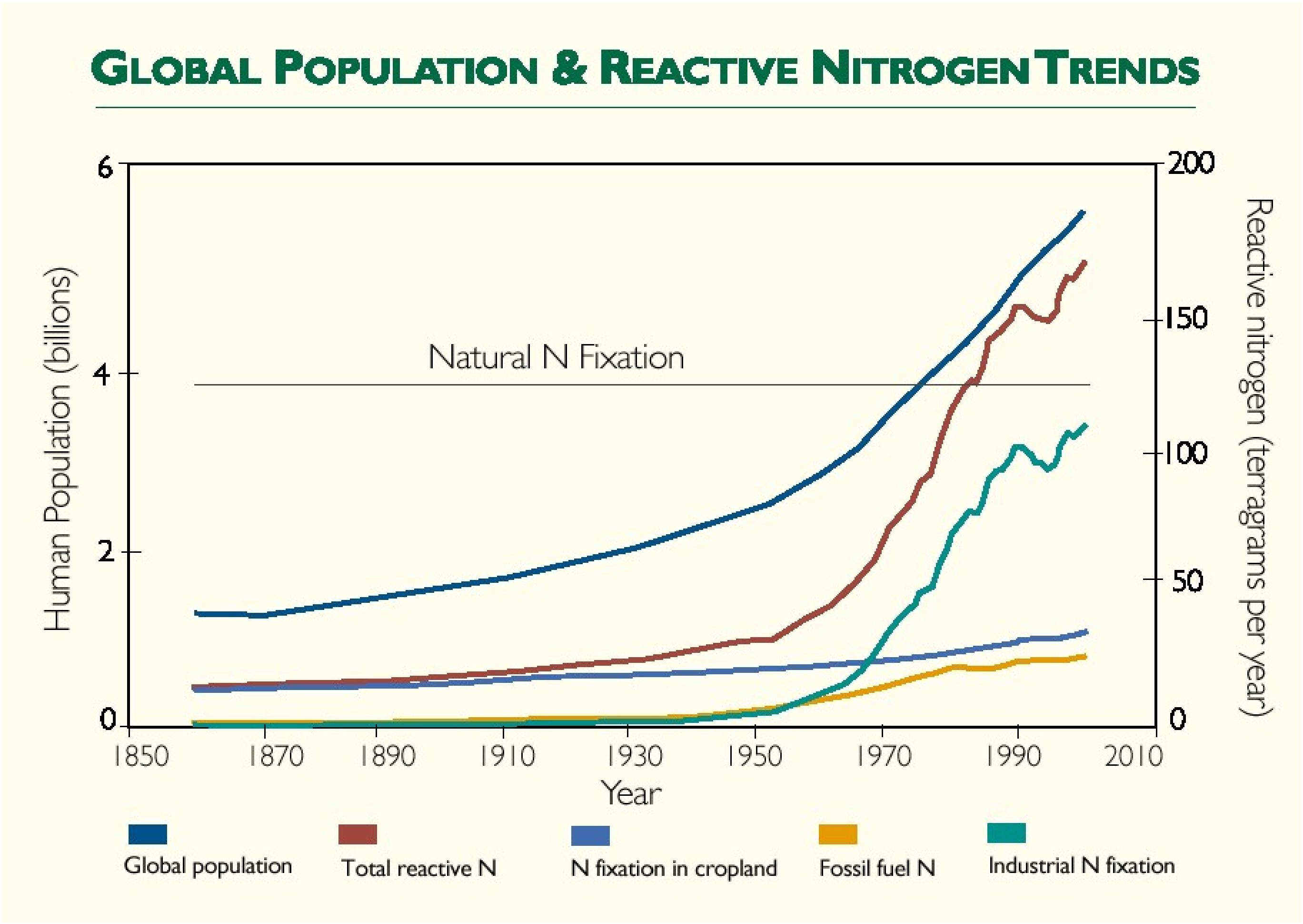
Nitrogen saturation

Biogeochemistry 79 (2006)

Why are we all talking nitrogen?

Why assess nitrogen in the environment?

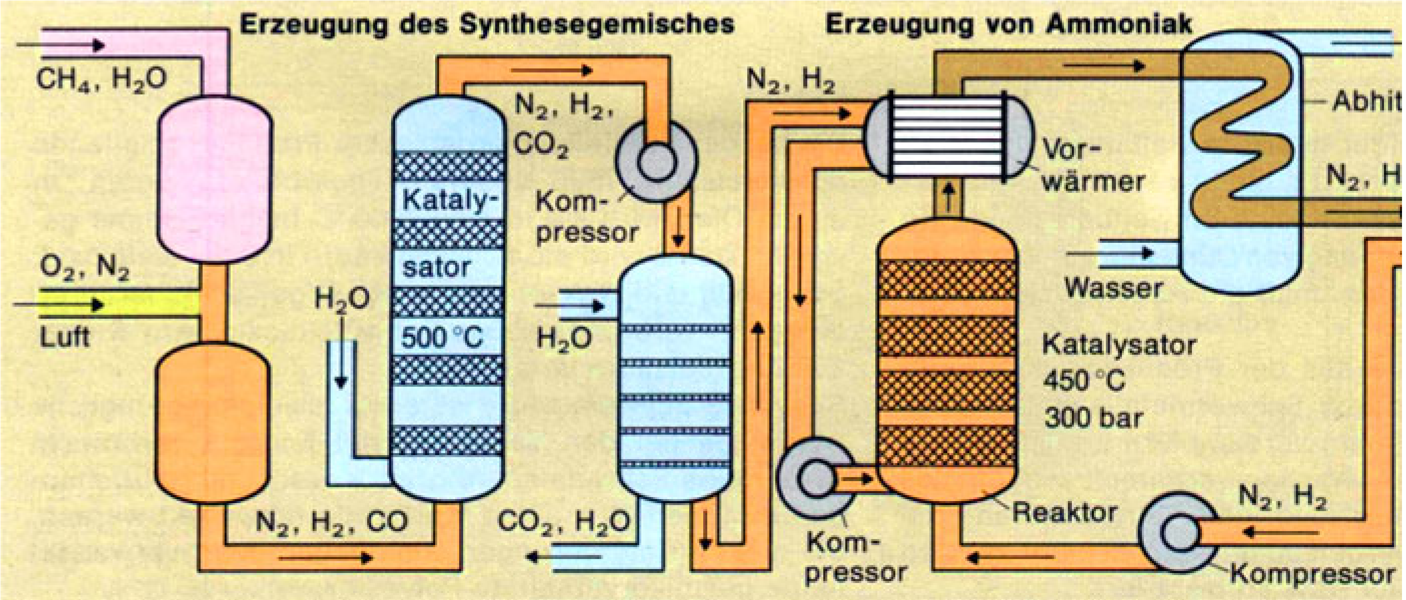
Nitrogen pollution is steadily increasing and has emerged as a pressing environmental issue of the 21st century.



source: www.hubbardbrook.org/hbrf

source: www.initrogen.org

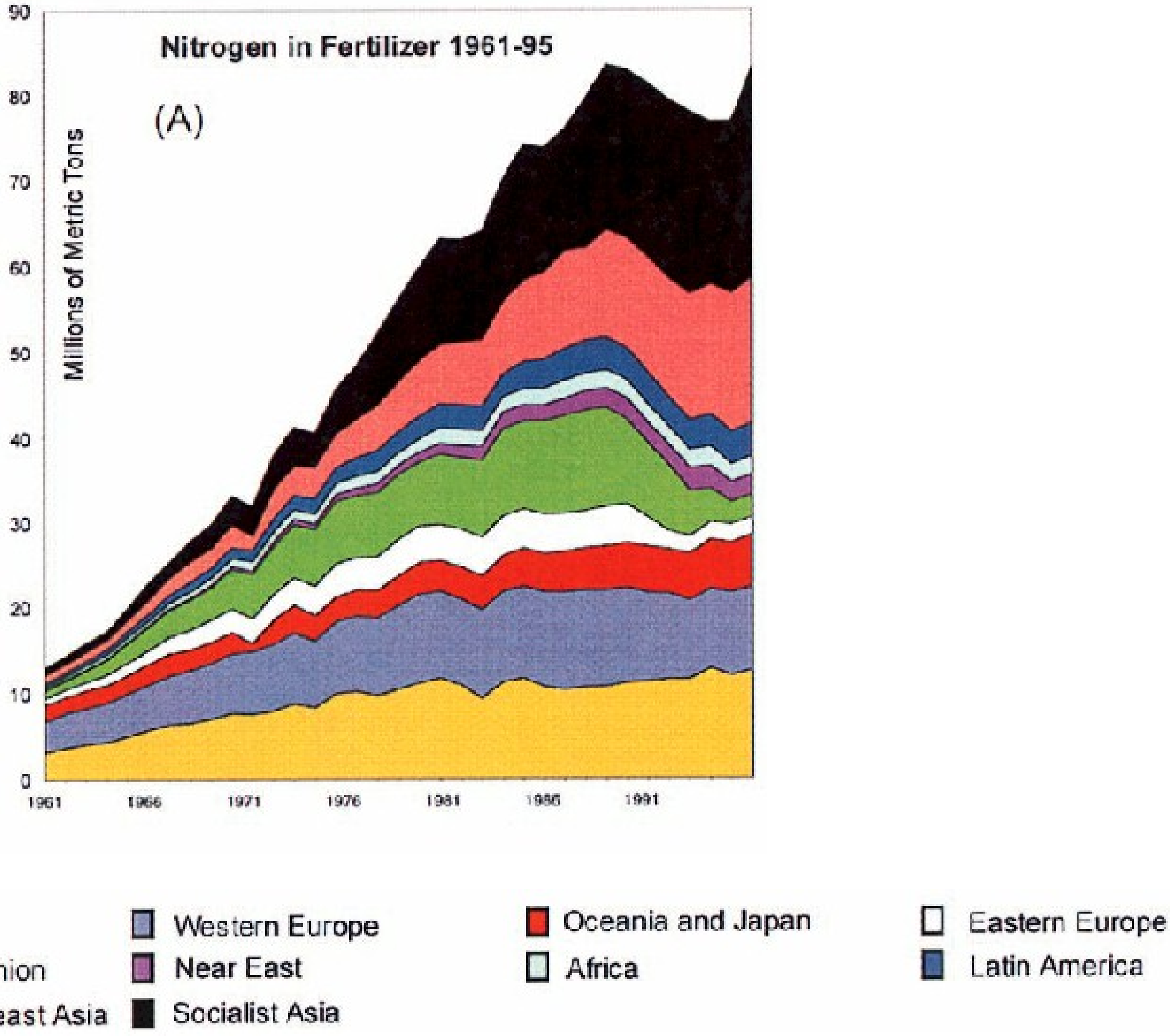
source: www.initrogen.org



source: www.initrogen.org

source: www.initrogen.org

source: www.initrogen.org

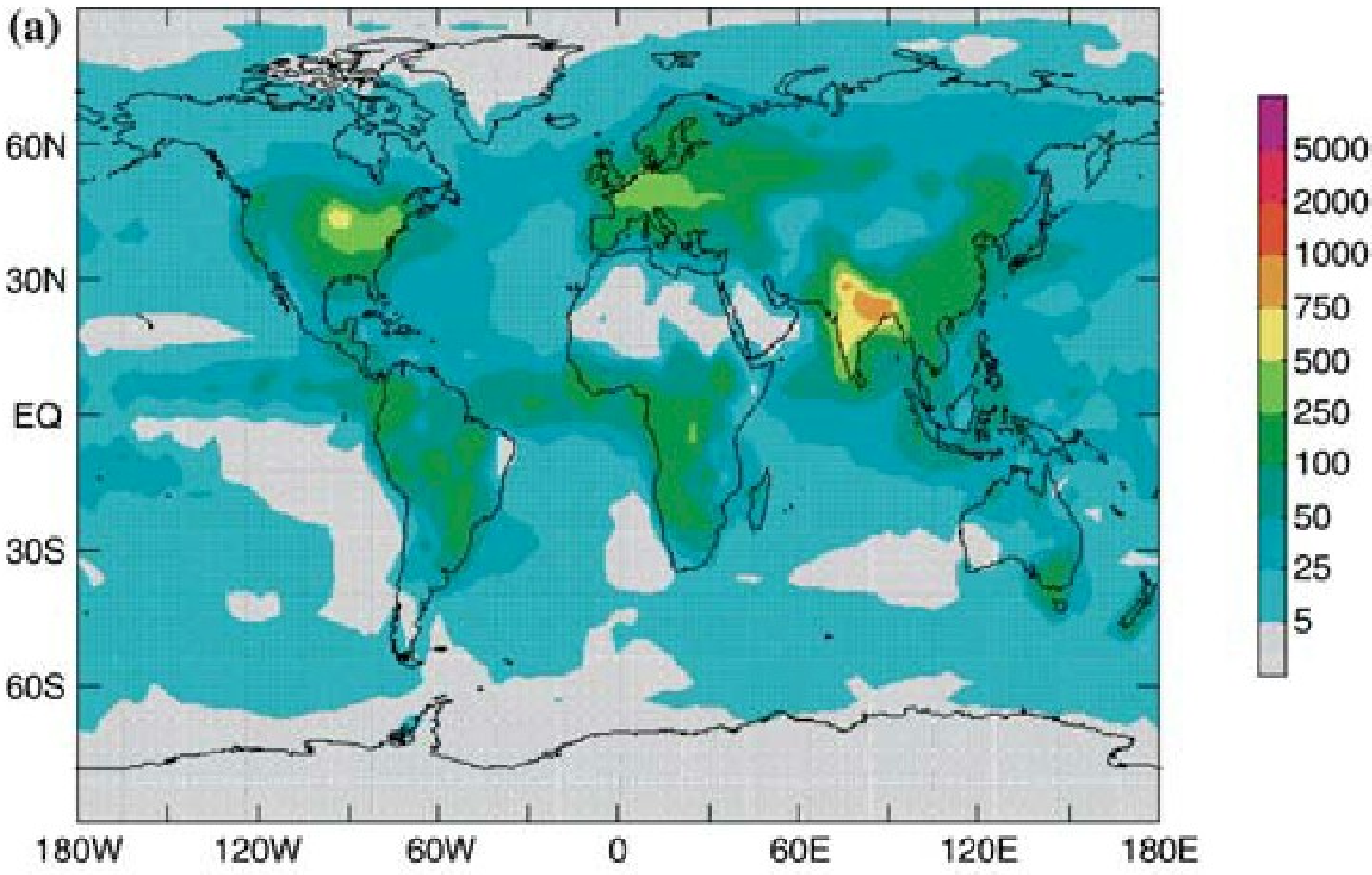


source: Socolow 1999

source: www.initrogen.org

source: www.initrogen.org

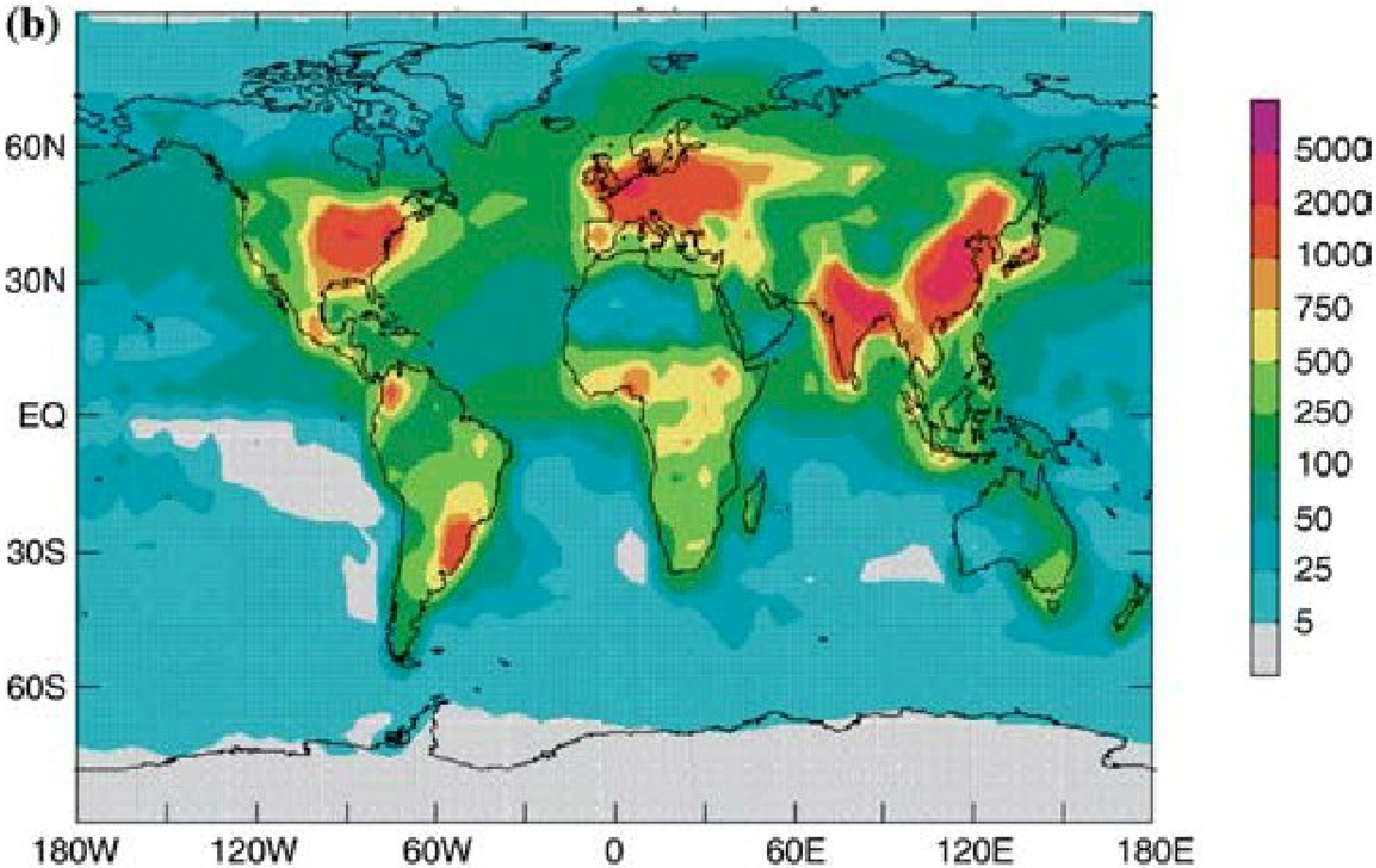
1860



Spatial patterns of total inorganic nitrogen deposition (mg N m^{-2} yr^{-1})

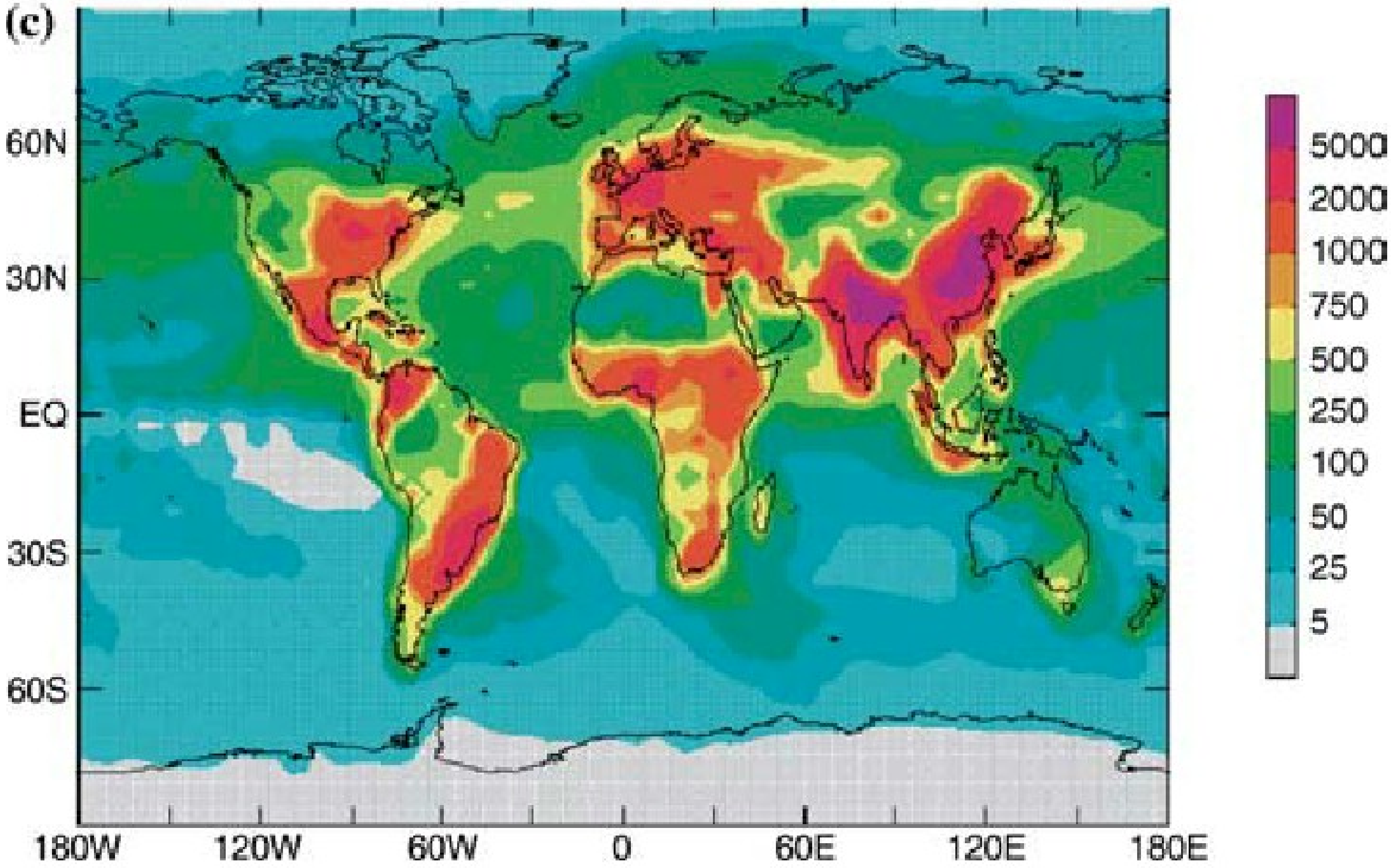
source: Galloway et al. 2004

1990

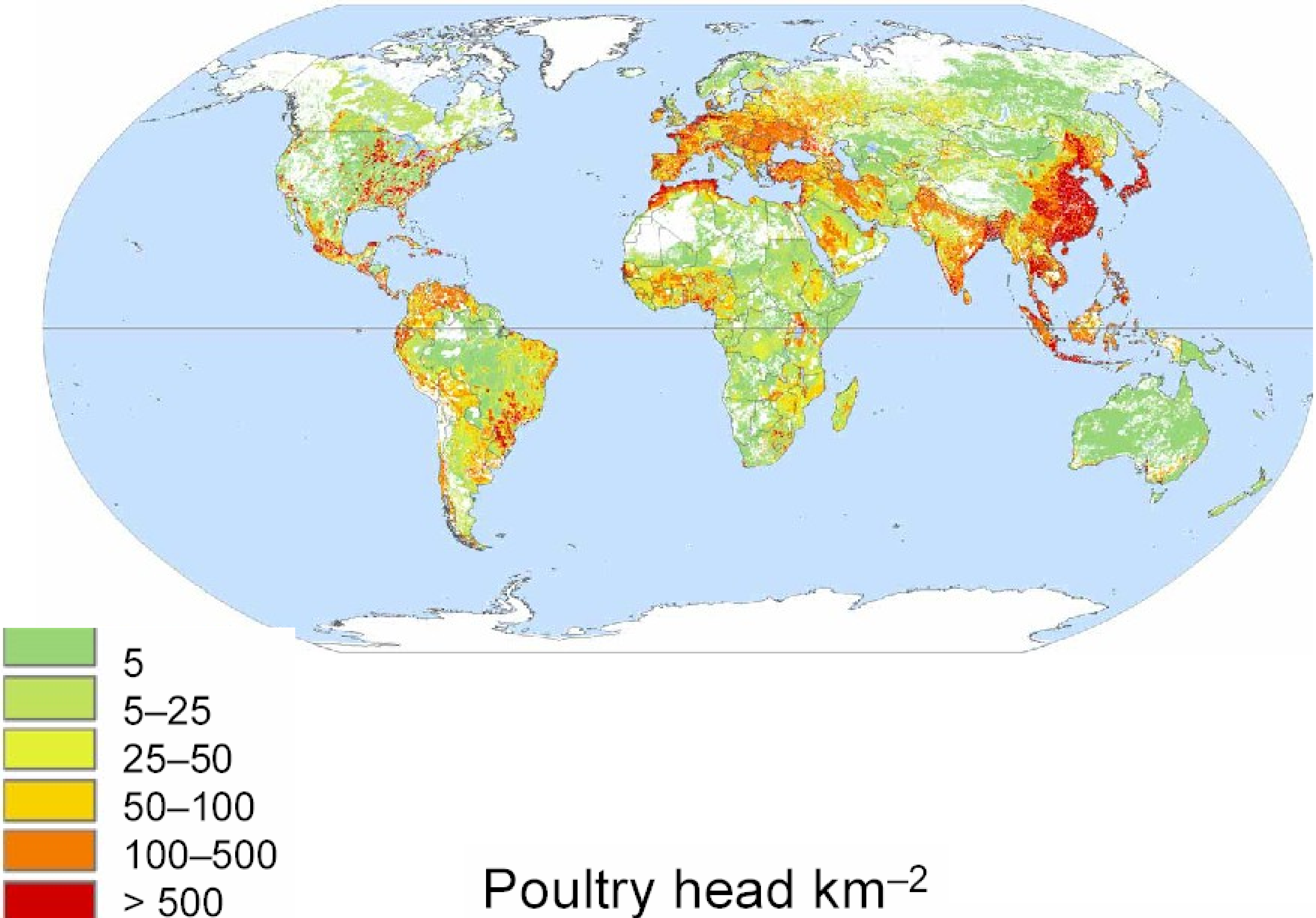


source: Galloway et al. 2004

2050



source: Galloway et al. 2004



source: Galloway 2006

How does nitrogen become a pollutant?

Nitrogen becomes a pollutant when more reactive nitrogen is released into the environment than can be assimilated without degrading air, land and water resources.

source: www.hubbardbrook.org/hbrf

What are the ecological effects of nitrogen pollution in the Northeast?

Nitrogen pollution contributes to ground-level ozone, acid rain and acidification of soil and surface waters, disruption of forest processes, coastal over-enrichment and other environmental issues.

source: www.hubbardbrook.org/hbrf

The Cascade of Nitrogen Pollution

Air quality impacts:

~ Elevated ground-level ozone
~ Increased particles in the air
~ Reduced visibility
~ Increased acid rain and nitrogen deposition

↓

Forest impacts:

~ Increased acidity of forest soils
~ Nitrogen saturation of forest ecosystems
~ Ozone damage to forests

↓

Water quality impacts:

~ Elevated acidification of lakes and streams
~ Groundwater contamination
~ Over-enrichment of coastal ecosystems

Other impacts:

~ Increased production of greenhouse gases contributing to global climate change
~ Adverse human health effects from particulate matter and ground-level ozone

source: www.hubbardbrook.org/hbrf

Table 1. Beneficial and detrimental effects of reactive nitrogen (Nr).

Direct effects of Nr on human health include:

- Increased yields and nutritional quality of the foods needed to meet dietary requirements and food preferences for growing populations.
- Respiratory and cardiac disease induced by exposure to high concentrations of ozone and fine particulate matter.
- Nitrate and nitrite contamination of drinking water leading to the "blue-baby syndrome" and certain types of cancer.
- Blooms of toxic algae, with resultant injury to humans.

Direct effects of Nr on ecosystems include:

- Increased productivity of Nr-limited natural ecosystems.
- Ozone-induced injury to crop, forest, and natural ecosystems and predisposition to attack by pathogens and insects.
- Acidification and eutrophication effects on forests, soils, and freshwater aquatic ecosystems.
- Eutrophication and hypoxia in coastal ecosystems.
- N saturation of soils in forests and other natural ecosystems.
- Biodiversity losses in terrestrial and aquatic ecosystems and invasions by N-loving weeds.
- Changes in abundance of beneficial soil organisms that alter ecosystem functions.

Indirect effects of Nr on other societal values include:

- Increased wealth and well being of human populations in many parts of the world.
- Significant changes in patterns of land use.
- Regional hazes that decrease visibility at scenic vistas and airports.
- Depletion of stratospheric ozone by N_2O emissions.
- Global climate change induced by emissions of N_2O and formation of tropospheric ozone.
- Damage to useful materials and cultural artifacts by ozone, other oxidants, and acid deposition.
- Long-distance transport of Nr which causes harmful effects in countries distant from emission sources and/or increased background concentrations of ozone and fine particulate matter.

In addition to these effects, it is important to recognize that:

- The magnitude of Nr flux often determines whether effects are beneficial or detrimental.
- All of these effects are linked by biogeochemical circulation pathways of Nr.
- Nr is easily transformed among reduced and oxidized forms in many systems. Nr is easily distributed by hydrologic and atmospheric transport processes.

The identification of 100 ecological questions of high policy relevance in the UK

46. What impact does plastic-derived litter have on the marine environment?
47. How can one ameliorate the effects of aerially deposited nitrogen on habitats and species?
48. What are the critical thresholds for nitrogen and phosphorus inputs into waterbodies of high conservation value?

Journal of Applied Ecology 2006
43, 617–627

45. What are the effects of domestic cats on vertebrate populations in rural and urban environments?

Key questions. what are the:

Issues identified with nitrogen emissions in other jurisdictions?

Management approaches used: successes and failures?

Management approaches with respect to both emissions management and effects management?

How are these relevant to the AB situation?

Flat-rate reductions…

a reduction in [nitrogen] emissions of a fixed percentage [relative to a set year]

neither economically nor environmentally efficient

Nitrogen management and the future of food: Lessons from the management of energy and carbon

ROBERT H. SOCOLOW*

Center for Energy and Environmental Studies, Princeton University, Princeton, NJ 08544

Efforts already underway to manage human impacts on the carbon cycle suggest five principles that could guide first steps to manage human impacts on the nitrogen cycle: (*i*) reach agreement on goals relevant to sustainability; (*ii*) improve efficiency of producers and consumers throughout the system; (*iii*) harness market forces; (*iv*) incorporate mechanisms to learn continuously from research; and (*v*) engage the consumer and the citizen. In a properly crafted management system, these five prescriptions can be mutually supportive.

Proc. Natl. Acad. Sci. USA
Vol. 96, pp. 6001–6008, May 1999
Colloquium Paper

James N. Galloway, Ellis B. Cowling, Sybil P. Seitzinger and Robert H. Socolow

Reactive Nitrogen: Too Much of a Good Thing?

To achieve this desirable integration, mathematical assessment models and other management tools must be developed and used to help environmental managers and stakeholders in government, industry, and public-interest groups better understand: a) the complexity of nitrogen-management problems; b) the advantages and limitations of alternative food and energy production systems; and c) the necessity of improved communication among all stakeholders (27).

Ambio Vol. 31 No. 2, March 2002

source: www.initrogen.org

Case study: the UNECE convention of LRTAP

The convention on LRTAP is one of the main international efforts to combat acidification and other damages to ecosystems, buildings, and human health in Europe and North America. Since 1979, eight protocols on different pollutants and procedural matters of the convention have been signed under the auspices of the UNECE. The convention has set up a multi-layer organisation to include scientific assessments on the numerous technical and scientific questions of air-pollution.

Environmental Science & Policy 5 (2002) 421–427

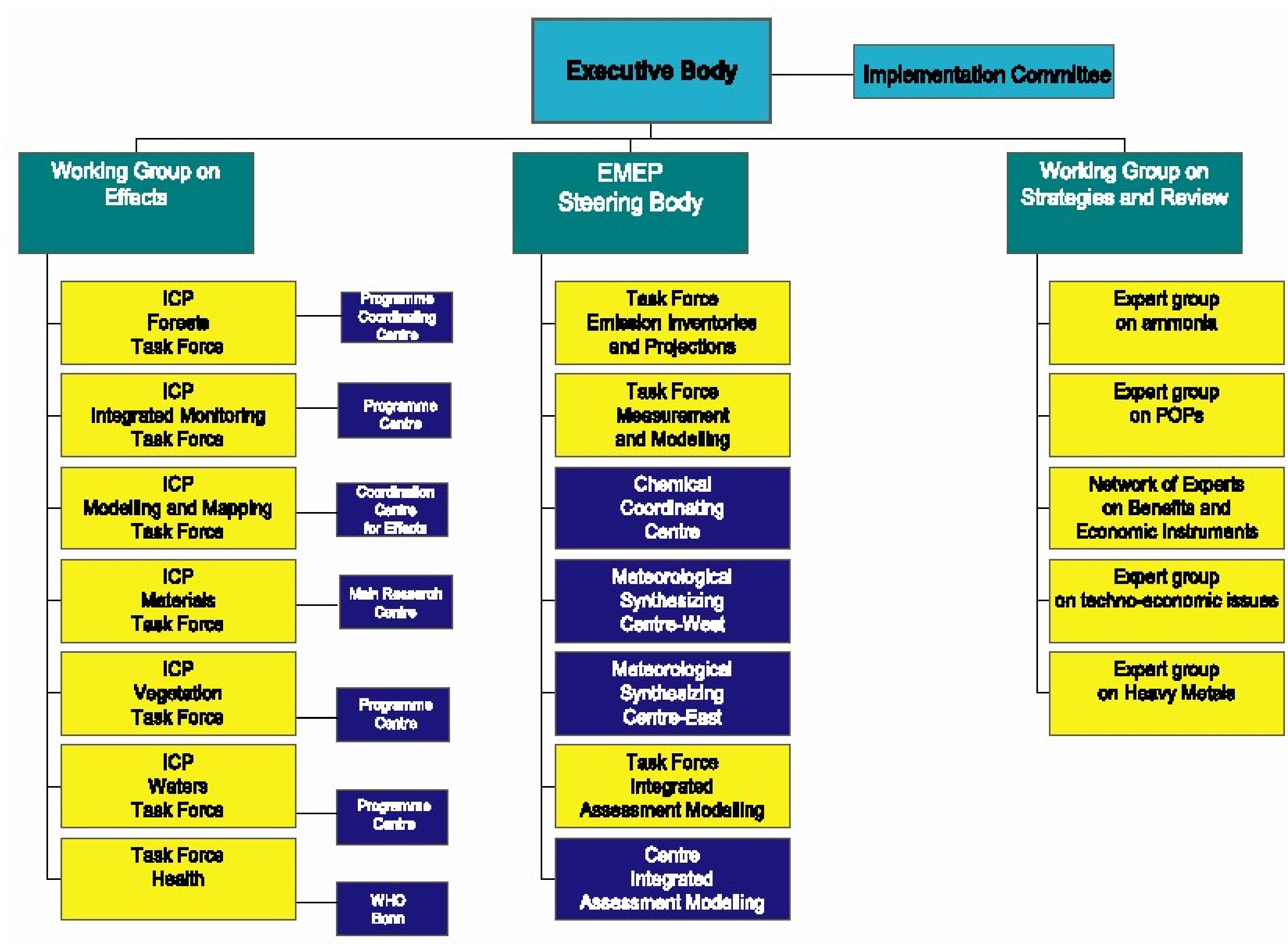
How do scientific assessments learn?
Part 2. Case study of the LRTAP assessments and comparative conclusions

Bernd Siebenhüner*

Potsdam Institute for Climate Impact Research (PIK), Global Governance Project, P.O. Box 60 12 03, 14412 Potsdam, Brandenburg, Germany

Why was (is) the UNECE convention of LRTAP so successful?

An effective organisational structure was set-up



source: www.icpmapping.org

A first important step was the formal creation of the EMEP [1] Protocol, which established a mechanism for the financing of a modeling and monitoring program.

By collecting, processing and analysing air-pollution data, EMEP was the precondition for both, for the political negotiations and for scientific advice.

source: Siebenhüner 2002

[1] Co-operative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe

One of the problems the National Acid Precipitation Assessment Programme (NAPAP) faced in the United States was conflict between several models describing the atmospheric transfer of pollutants. The lack of agreement on adopting a single model was one factor that hindered a political agreement on emission reductions and was used as an argument against exploring receptor based strategies [17].

source: Gough et al. 1997

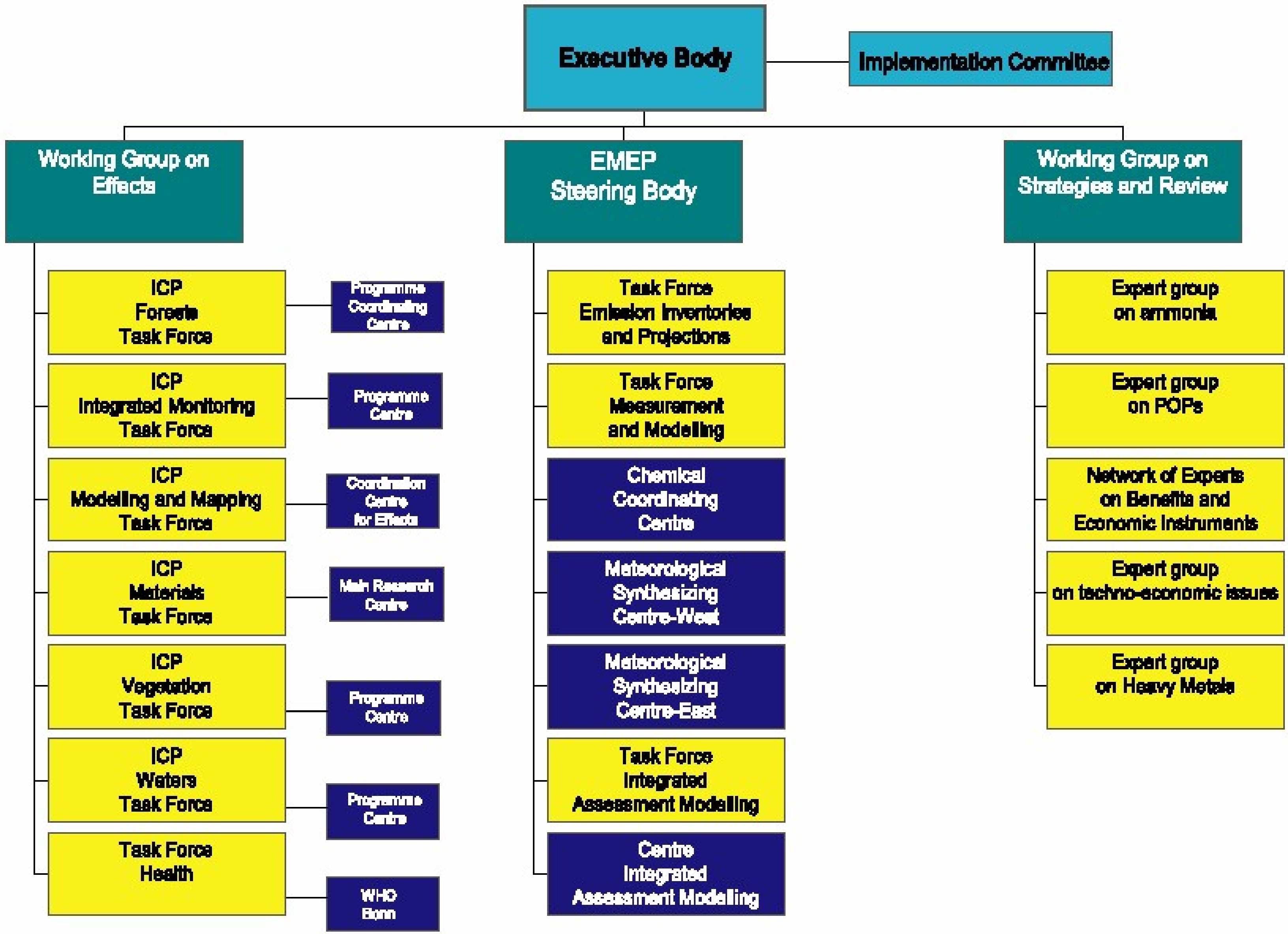
In North America, debate concerning the atmospheric transfer of pollutants was not diminished by increased scientific activity; this simply accentuated controversy. In Europe the desired closure was achieved *a priori* by electing a respected group of scientists subject to a specially created review process to ratify their science, and hence avoid deflecting debate away from the real issue of national emission reduction commitments.

source: Gough et al. 1997

Working Group on Effects

very early stage in the convention process, the Working Group on Effects came into being to provide the scientific information on which the negotiations of further protocols were based. It collected its information from a number of special international programmes focusing on the different effects of air-pollution, such as soil degradation, damages to forests and alike.

source: Siebenhüner 2002



source: www.icpmapping.org

the 1985 Helsinki Protocol for the reduction of sulphur emissions and its transboundary fluxes established a reduction in sulphur emissions of at least 30% (relative to their 1980 levels), and was signed by 20 parties of the Convention ("the 30% Club").

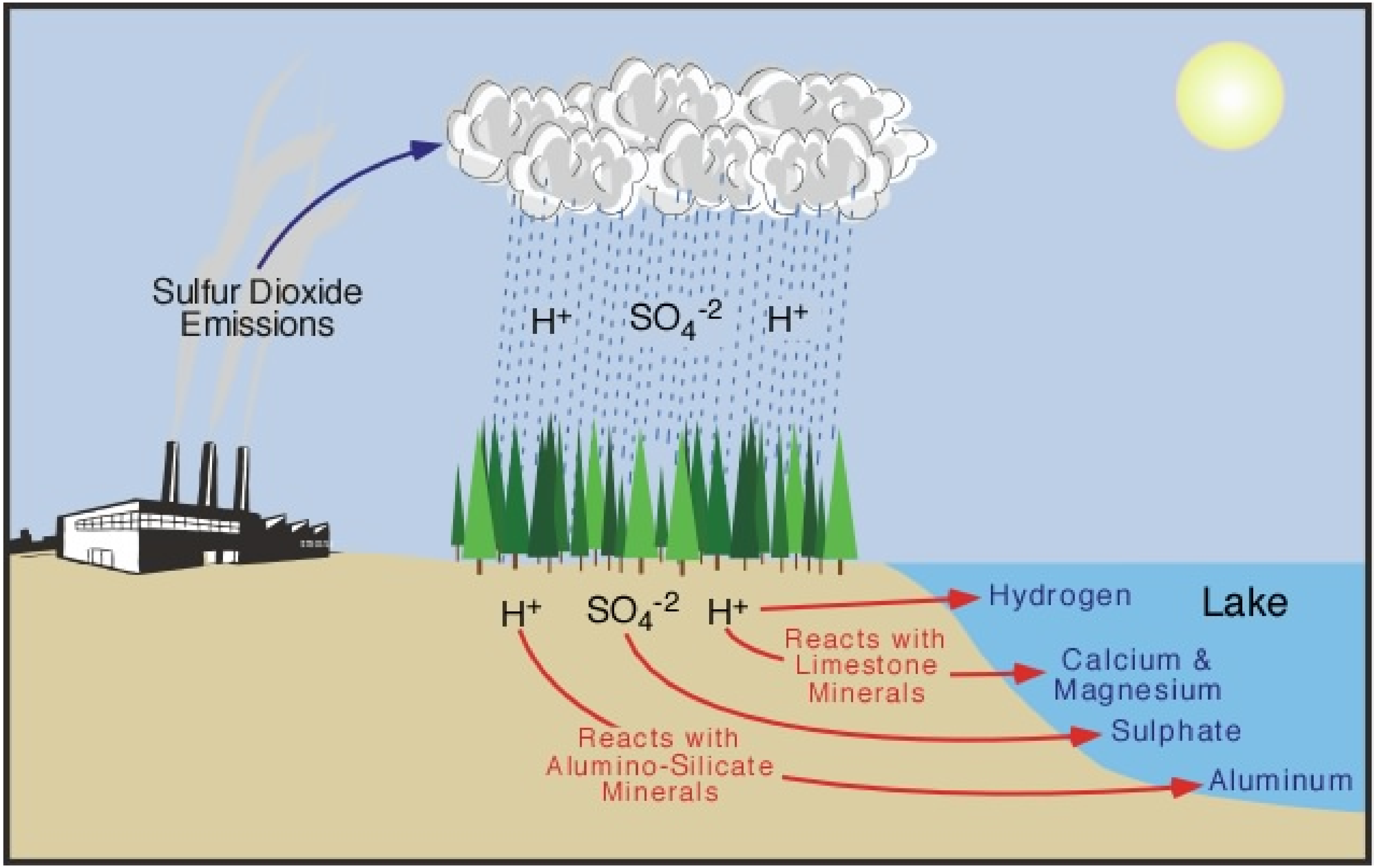
Although it represents initial positive action, an agreement such as this, incorporating flat rate reductions, is considered neither economically nor environmentally efficient.

source: Gough et al. 1997

source: www.initrogen.org

Progressing from the Helsinki Protocol, the 1994 Oslo Protocol on further reduction of sulphur emissions [50] aimed to address these issues and to create new effects based protocols by adopting the critical loads approach and striving for cost-effectiveness.

source: Gough et al. 1997



source: www.physicalgeography.net

What was the critical-loads concept about that it managed to revolutionise the political as well as the assessment processes of the convention?

In essence, this concept focused on the regional damages and approached pollution control from this end in order to effectively protect ecosystems and human health (Bull, 1992, 1995). By contrast, previous pollution abatement strategies concentrated on overall emission reductions at all sources largely irrespective of the actual damages of specific emissions in certain regions. While it was mostly a matter of political negotiation over how many emissions have to be reduced, in the critical-loads approach, the different emission reduction requirements could be deduced for different regions. This allows for more cost-effectiveness in abatement strategies.

source: Siebenhüner 2002

"The aim of the critical load approach is that pollutant emission reductions should be negotiated on the basis of the effects of air pollutants, rather than choosing an equal percentage emission reduction for all countries involved. The goal is to reduce, in a cost-effective manner and wherever possible, emissions of pollutant substances to levels where, ultimately, critical loads are not exceeded."

source: Gough et al. 1997

"the concept was virtually revolutionary in diplomacy because it assigned differential national obligations based on the carrying capacity of vulnerable ecosystems rather than a politically equitable (and arbitrary) emission cut."

Haas Mand McCabe, 2001

source: Siebenhüner 2002

source: www.initrogen.org

In the LRTAP convention, the crucial means to link scientific data on actual damages and environmental stresses with the political processes under the critical-loads approach was the RAINS model—an integrated assessment model developed by IIASA.[5]

source: Siebenhüner 2002

Integrated Assessment: a methodology for complex issues

A seminal example, in Europe, is the case of the development of acidification policies within the United Nations Economic Commission for Europe (UNECE).

The UNECE approached these goals by employing IA models to analyse the distribution of emissions, abatement costs and acidic deposition in relation to critical loads.

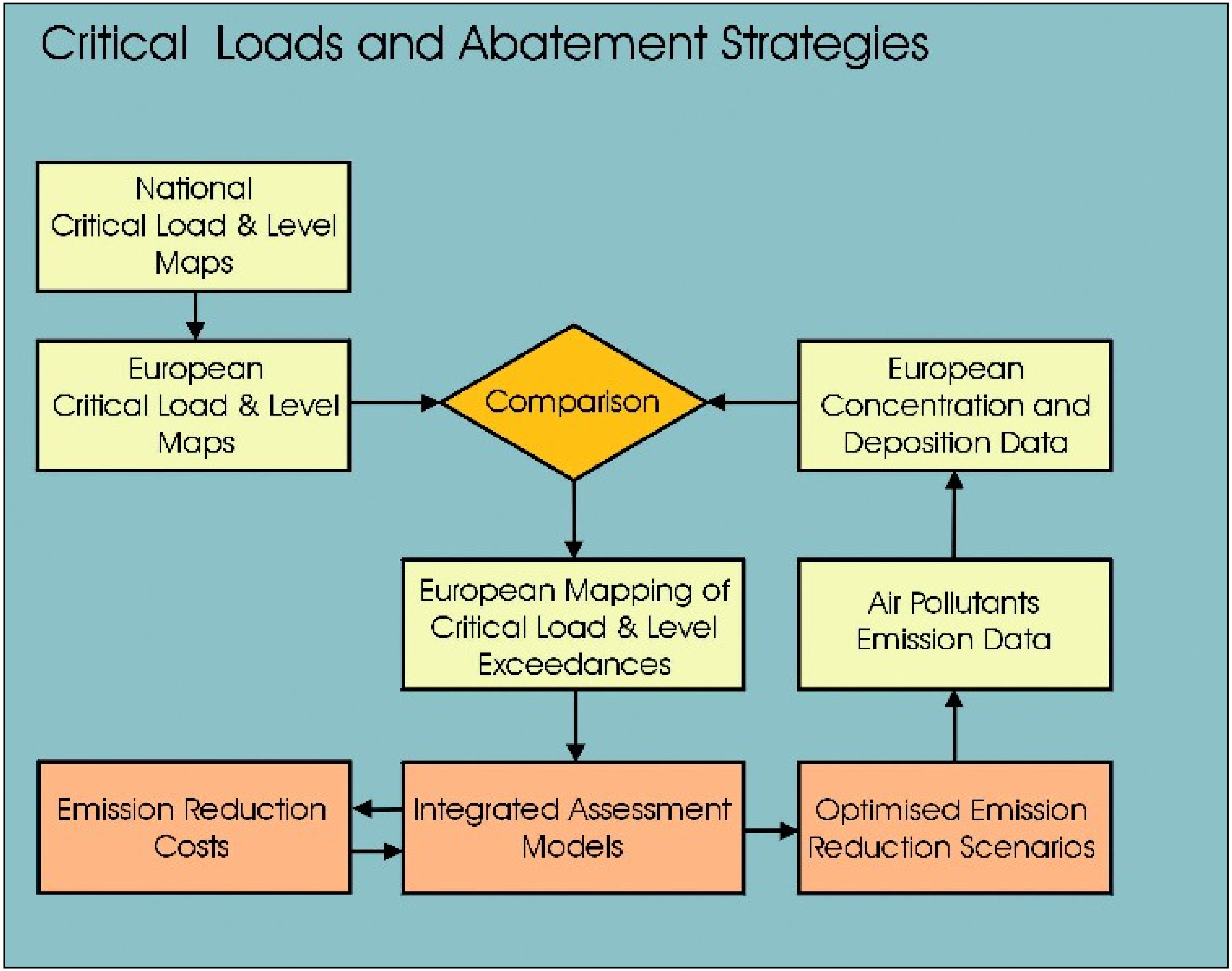
Environmental Modeling and Assessment 3 (1998) 19–29

Integrated Assessment: an emerging methodology for complex issues

Clair Gough, Nuria Castells and Silvio Funtowicz

"The negotiation of the protocol [Sulphur Protocol] marks the first time that all parties to a major international treaty have accepted a computer simulation model – the Regional Acidification Information and Simulation Model, RAINS, developed at IIASA – and made it an integral part of their negotiations. The negotiators accepted RAINS because it helped them to keep the talks on a sound scientific footing and, in the end, to negotiate a deal that gives the most environmental protection for the least money."

source: Gough et al. 1997



source: www.icpmapping.org

EMISSION INVENTORIES, EMISSION CONTROL OPTIONS AND CONTROL STRATEGIES: AN OVERVIEW OF RECENT DEVELOPMENTS

M. AMANN
International Institute for Applied Systems Analysis (IIASA), A-2361 Laxenburg, Austria
(author for correspondence, e-mail: amann@iiasa.ac.at)

During the last decade innovative concepts for emission control legislation were developed. Market based instruments can achieve envisaged emission reductions at lower costs than conventional approaches. Air quality management is now understood as a multi-pollutant, multi-effect task, which offers a significant cost saving potential if synergistic effects are fully utilized. Integrated assessment models proved useful in managing the vast volume of relevant information needed for the design of cost-effective emission control strategies.

Water, Air, and Soil Pollution **130:** 43–50, 2001.

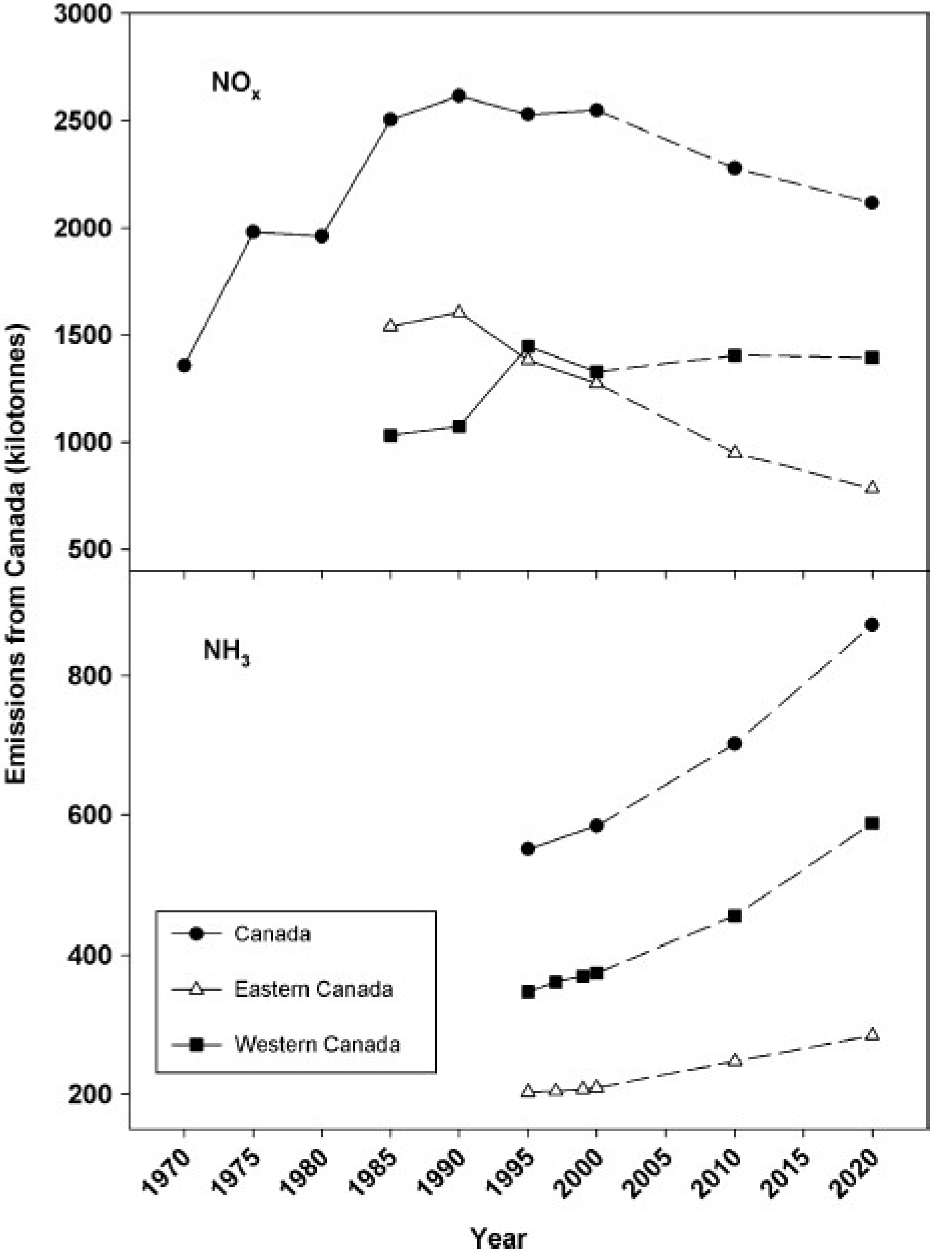
Key questions. what are the:

Issues identified with nitrogen emissions in other jurisdictions?

Management approaches used: successes and failures?

Management approaches with respect to both emissions management and effects management?

How are these relevant to the AB situation?



Biogeochemistry (2006) 79: 25–44
DOI 10.1007/s10533-006-9001-2

A review of anthropogenic sources of nitrogen and their effects on Canadian aquatic ecosystems

DAVID W. SCHINDLER[1,]*, PETER J. DILLON[2]
and HANS SCHREIER[3]

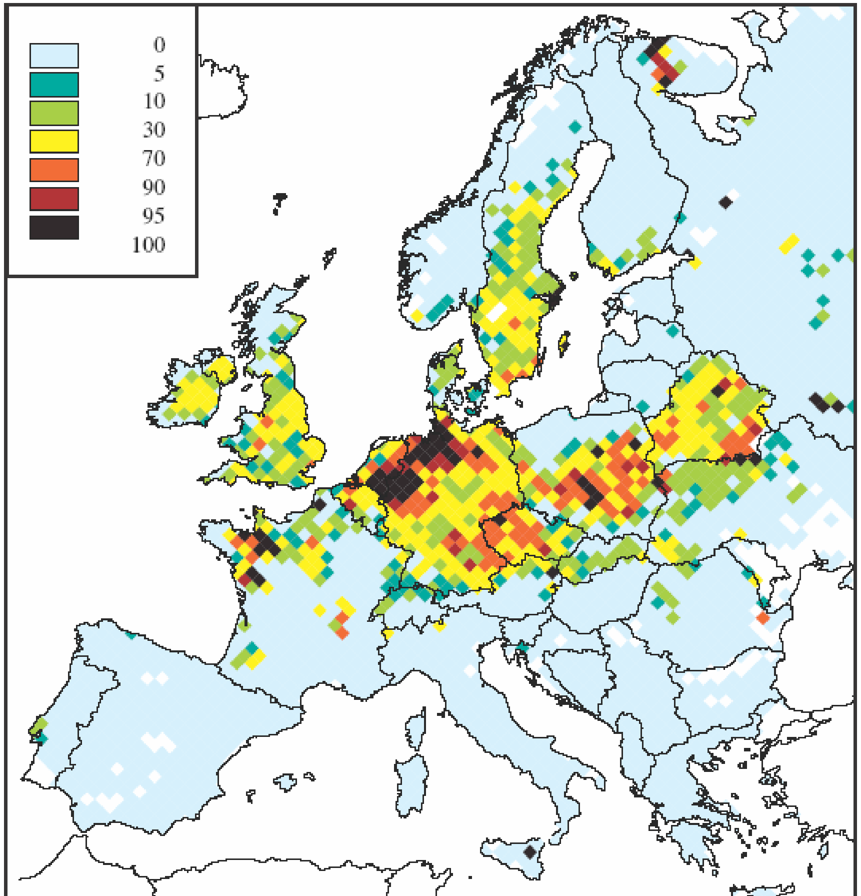
source: www.initrogen.org

My management approaches for nitrogen emissions shopping list

1. Effective organisational structure to include:
   a) a working group on effects
   b) agreed upon atmospheric transport model[ling group]
   c) an Integrated Asessment model[ling group]

2. An effects-based approach to emissions reductions

Acid deposition to forests 2020

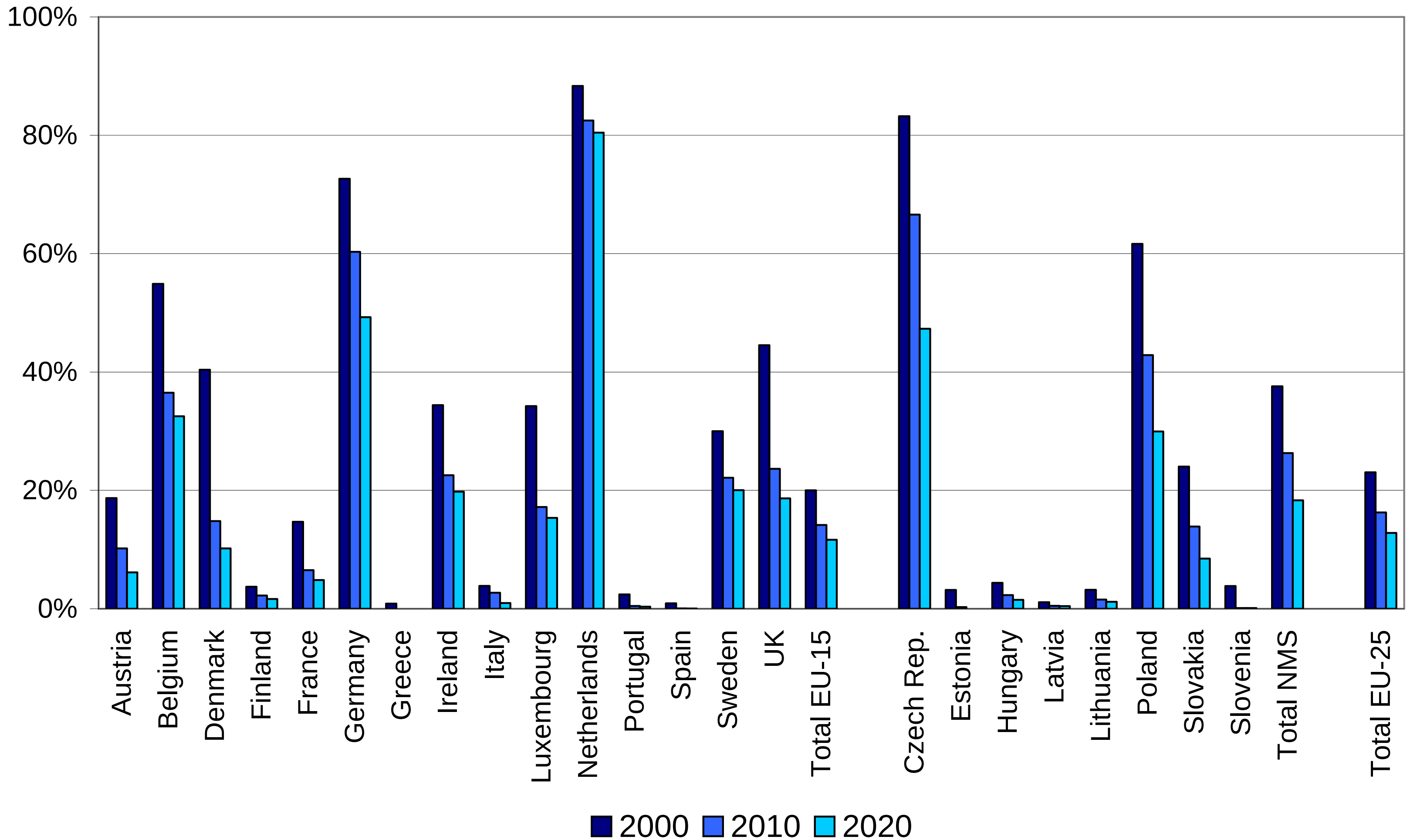


Percentage of forest area with acid deposition above critical loads, using ecosystem-specific deposition, Average of calculations for 1997, 1999, 2000 & 2003 meteorologies

source: Markus Amann @ iiasa

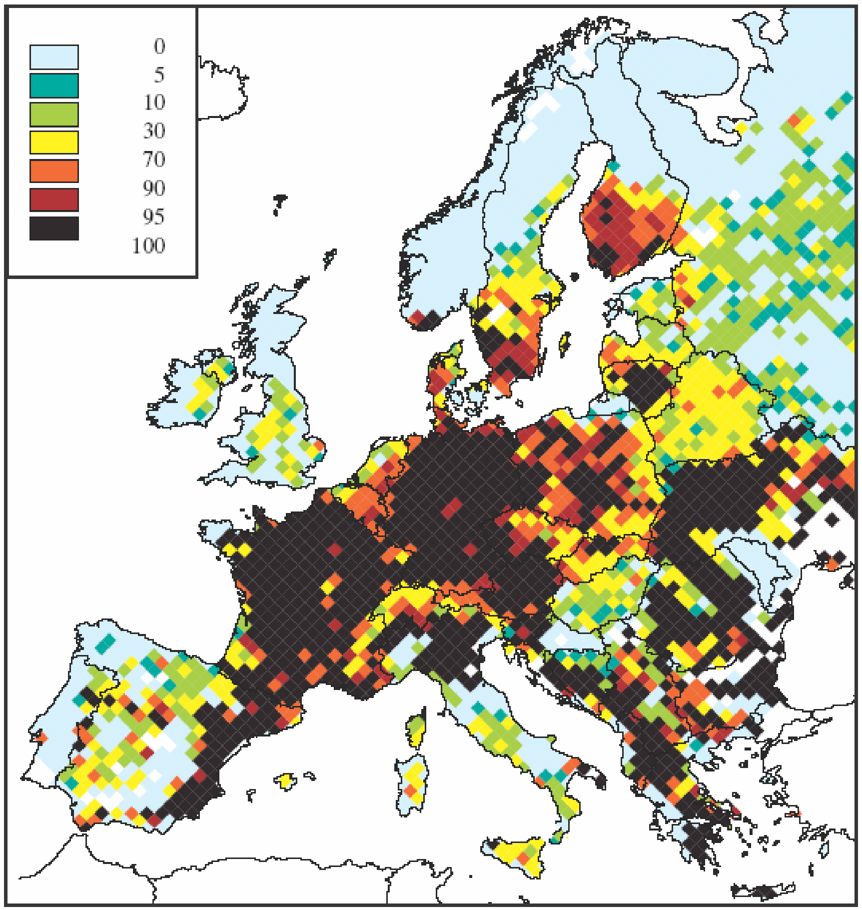
Percent of forest area

with acid deposition above critical loads



source: Markus Amann @ iiasa

Excess of critical loads for eutrophication 2020

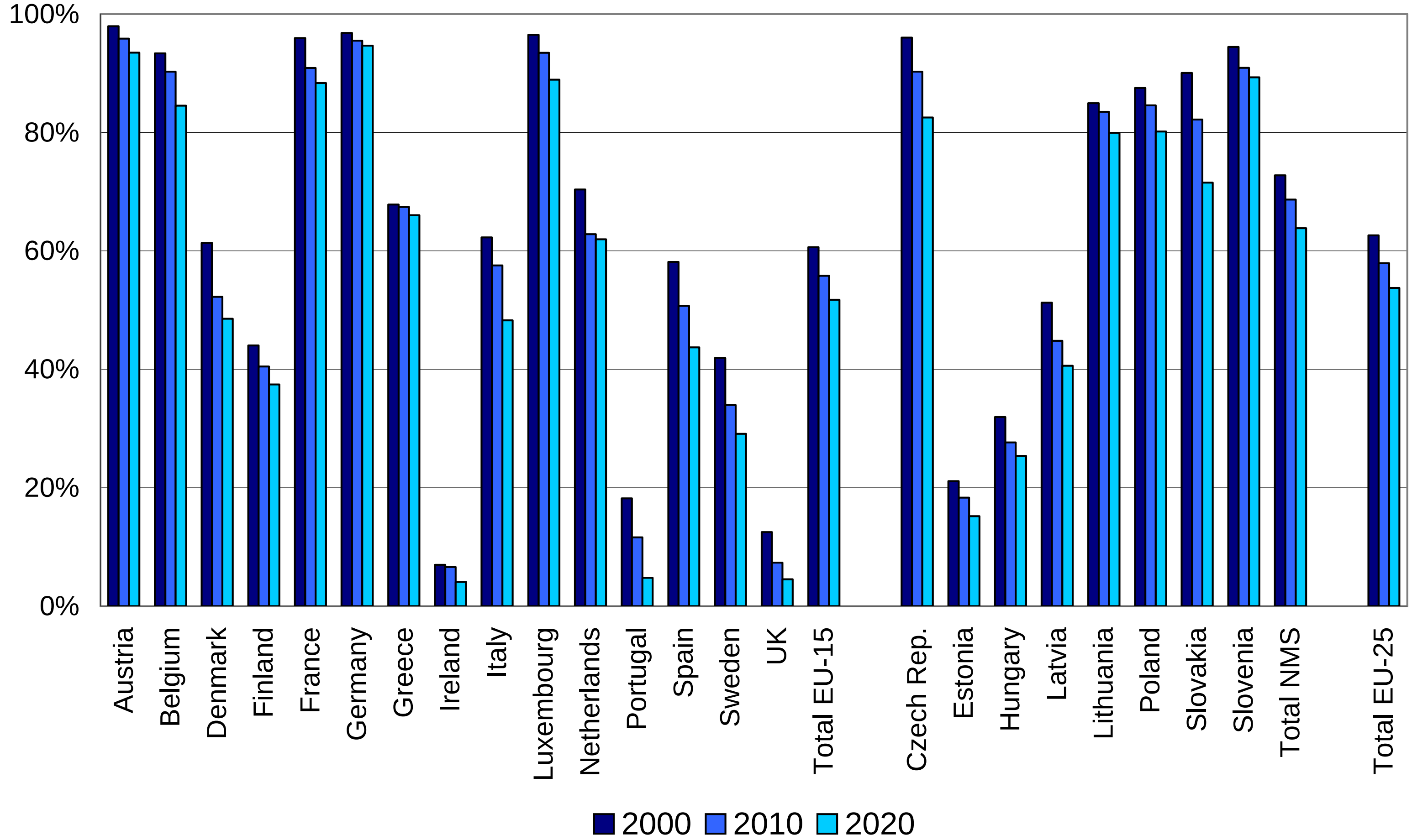


Percentage of ecosystems area
with nitrogen deposition above critical loads, using grid-average deposition.
Average of calculations for 1997, 1999, 2000 & 2003 meteorologies

source: Markus Amann @ iiasa

Percent of ecosystems area

with nitrogen deposition above critical loads for eutrophication



source: Markus Amann @ iiasa

Conclusions

- With decreasing pollution, also impacts are expected to decline in the future.
- However, problems will not be entirely resolved:
  - PM remains serious (~5 months life expectancy loss in 2020)
  - Ozone:
    - Remains a significant cause for premature deaths (Several 1000 cases in 2020)
    - Vegetation damage:
      Wide-spread violations of AOT40 critical level will prevail
  - Acidification: Will not disappear, mainly due to NH_3
  - Eutrophication remains unresolved

source: Markus Amann @ iiasa

source: www.initrogen.org

References

Amann M, 2001. Emission inventories, emission control options and control strategies: An overview of recent developments. Water, Air and Soil Pollution,130, 43–50.

Amann M, Bertok I, Cofala J, Gyarfas F, Heyes C, Klimont Z, Schöpp W and Winiwarter W, 2005. Baseline Scenarios for the Clean Air for Europe (CAFE) Programme: Final Report. International Institute for Applied Systems Analysis, Austria, 79 pp.

Driscoll CT et al., 2003. Nitrogen Pollution: From the Sources to the Sea. Hubbard Brook Research Foundation. Science Links™ Publication. Volume 1, number 2 (online: www.hubbardbrook.org/hbrf).

Galloway JN and Cowling EB, 2002. Reactive nitrogen and the world: 200 years of change. Ambio 31:2, 64–71.

Galloway JN, 2006. Human Alteration of the Nitrogen Cycle: Implications for Plant Growth, Food Supply, Climate, Water Quality, and Human Health. American Meteorological Society Environmental Science Seminar Series, March 21, 2006

Galloway JN, Cowling EB, Seitzinger SP and Socolow RH, 2002. Reactive nitrogen: Too much of a good thing? Ambio 31:2, 60–63.

Galloway JN, Dentener FJ, Capone DG, Boyer EW, Howarth RW, Seitzinger SP, Asner GP, Cleveland CC, Green PA, Holland EA, Karl DM, Michaels AF, Porter JH, Townsend A.R. and Vörösmarty CJ, 2004. Nitrogen cycles: past, present, and future. Biogeochemistry 70, 153–226.

Gough C, Castells N and Funtowicz S, 1998 Integrated Assessment: an emerging methodology for complex issues, Environmental Modeling and Assessment 3, 19–29.

Schindler DW, Dillon PJ and Schreier H, 2006. A review of anthropogenic sources of nitrogen and their effects on Canadian aquatic ecosystems. Biogeochemistry 79, 25–44.

Siebenhüner B, 2002. How do scientific assessments learn? Part 2. Case study of the LRTAP assessments and comparative conclusions. Environmental Science and Policy 5, 421–427

Socolow RH, 1999. Nitrogen management and the future of food: Lessons from the management of energy and carbon. Proceedings of the National Academy of Sciences of the United States of America 96, 6001–6008

Sutherland WJ, Armstrong-Brown S, Armsworth PR et al., 2006. The identification of 100 ecological questions of high policy relevance in the UK. Journal of Applied Ecology 43, 617–627

UBA 2004. Manual on methodologies and criteria for modelling and mapping critical loads and levels and air pollution effects, risks and trends. Federal Environmental Agency (Umweltbundesamt), Berlin, Germany (online: www.icpmapping.org).