Critical loads development and use in Europe: Applicable to USA ?

Jean-Paul Hettelingh, Max Posch, Jaap Slootweg
Coordination Centre for Effects (CCE)[1]
www.pbl.nl/cce

[1]The CCE develops effect-based modelling methodologies and databases for the assessment of environmental effects in Integrated Assessment Models (GAINS) under the Convention on LRTAP with its network of National Focal Centres, and for the European Commission under the LIFE III project EC4MACS (LIFE06 PREP/A/06)

Outline
(focus on Nutrient nitrogen)

- Critical loads: What, why and how
- Inputs from National Focal Centres
- Challenges in the development and use of critical loads !

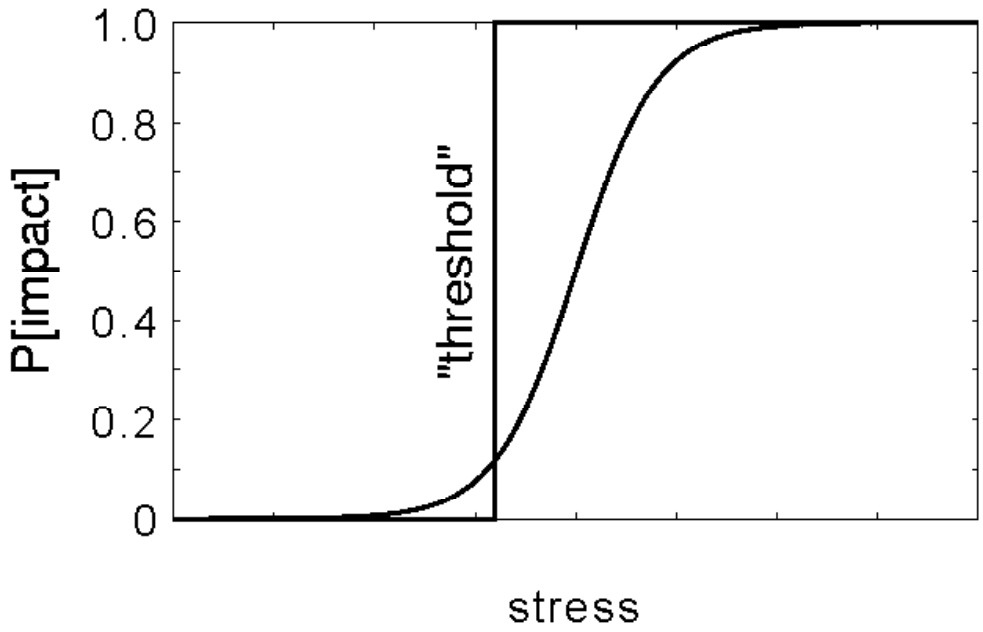
Critical loads: what, why and how

Terminology reminder:
Critical Load (**CL**, CLo): a deposition (flux) value
Critical Level (CLe): an ambient concentration value
Critical Flux: … into leaves (for ozone impacts)
General:
Critical Threshold: … all/any of the above

Damage Function and Critical Load (Threshold):

"In reality" there exist only (experimentally determined) **damage functions**, which often are (*or* have to be) interpreted probabilistically ("risk of damage")

Schematic example:



CL: The smooth function is replaced by a step-function (threshold)

Critical load; an early warning for excessive stress (deposition)

Early warning:

- "Critical load" means a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur,according to present knowledge;

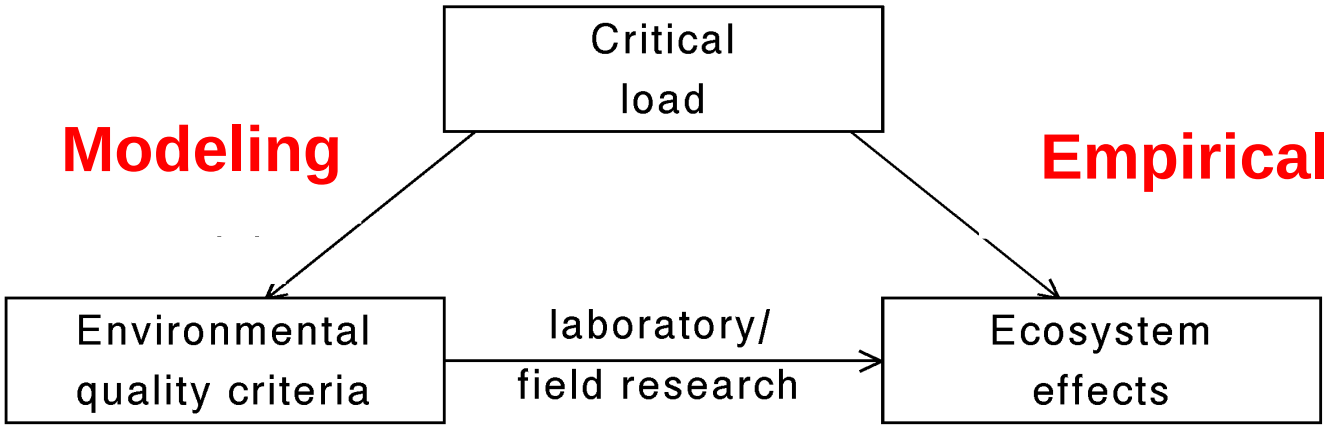
Is deposition = critical load sufficient for recovery ?:

- Recovery from adverse effects of acidification or eutrophication can be achieved when the critical load is not exceeded. *When recovery is required by a specified year (target year) a deposition value (target load) is required that enables the chemical criterion - that links the critical load to the biological effects - to attain a non-critical value in the target year.*

  Note: Target loads are computed using dynamic models !

Methods to derive critical loads

Empirical or modeling approaches



Empirical approach : limited to situations where "pollutant" input dominates effects (e.g. nitrogen i.r.t. biodiversity)

Modeling approach : applicable to all situations in which an environmental quality criterium does exist.

TRANSB04.TC

Source: De Vries …

Empirical critical loads

- **Europe:** Achermann B and Bobbink (2003), Empirical critical loads for nitrogen, Proceedings of an expert workshop, Berne, 11-13 November 2002.
- **USA:** Pardo *et al.* Assessment of N deposition effects and empirical critical loads of N for ecoregions of the United States (*in prep.).*
- **Europe, *next***: Workshop on the review and revision of empirical critical loads for nutrient N and dose response relationships, organised by the Coordination Centre for Effects in collaboration with the Federal Environmental Agencies from Switzerland and Germany, Noordwijkerhout, **23-25 June 2010**, Netherlands

Modeled critical load *of nutrient nitrogen and data requirements*

$$CL_{nut}(N) = N_{i(crit)} + N_{u(crit)} + \frac{Q \cdot [N]_{(crit)}}{1 - f_{de}}$$

Nitrogen immobilization. When assumed "natural" between 0.2-0.5 kg ha^{-1}yr^{-1}; Can include $N_{erosion,}$, N_{fire}, $N_{volatilisation}$,$N_{adsorption}$, N_{fix}.

Critical nitrogen leaching. Depends on runoff and Critical soils solution conc. The latter *vary from 0.2 mg N l^{-1} (N imbal.Conifers) to a range of 3-5 mg N l^{-1} for herbs to become grass*

Nitrogen uptake is based on nitrogen limitation concept, whereby N_u *depends on base cation deposition and weathering*

Denitrification, in Europe computed w/constant Denitrification fraction $f_{de;}$ 0.8 (peat soils), 0.7 (clay soils), 0.5 sandy soils, 0.1 loess soils

Source: CCE Status Report 1993 (www.pbl.nl/cce) and Mapping Manual, www. icpmapping.org

Inputs from National Focal Centres

NFC response for 2008 critical load database

(see CCE Status Report 2008, Ch. 2 & appendix B; www.pbl.nl/cce > publications)

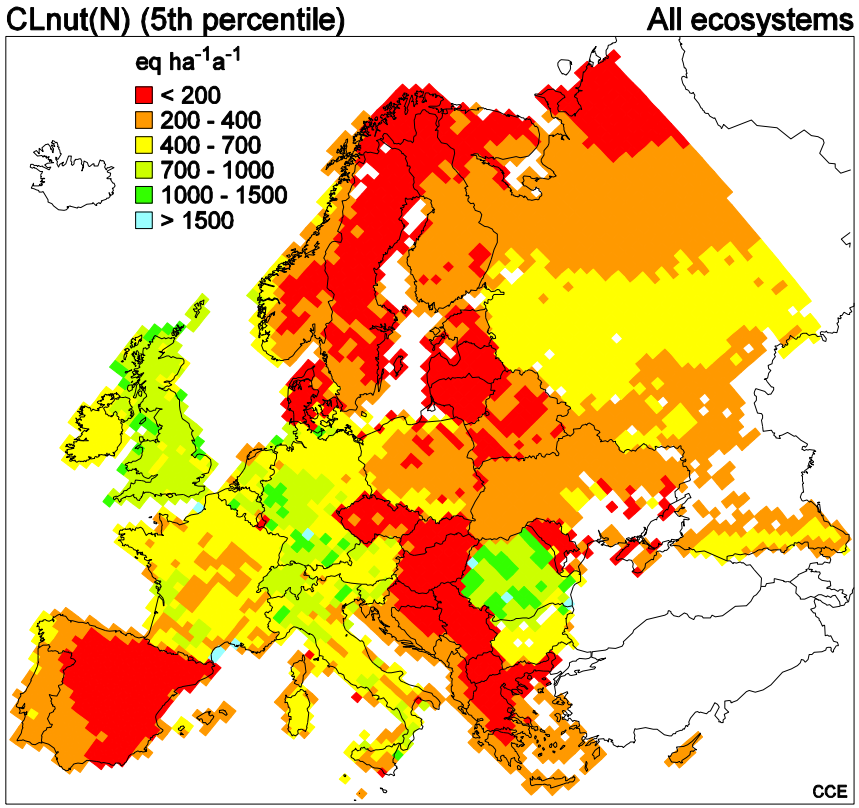
- National Focal Centres (NFCs) are asked to
  - Submit modeled critical loads for acidification and eutrophication (and data to compute them)
  - Submit empirical N critical loads
  - Area of the ecosystem within each EMEP grid cell
  - Protection characteristic (areas subject to e.g. Special Protection, Bird directive, Habitat directive…)
  - Code according to the European Nature Information System (EUNIS: 4 “forest”-, 6 “vegetation”-, 4 “other” classes)
- 20 parties to the Convention, including Canada, responded to the call.

Non-response: Apply CCE background (BG) database

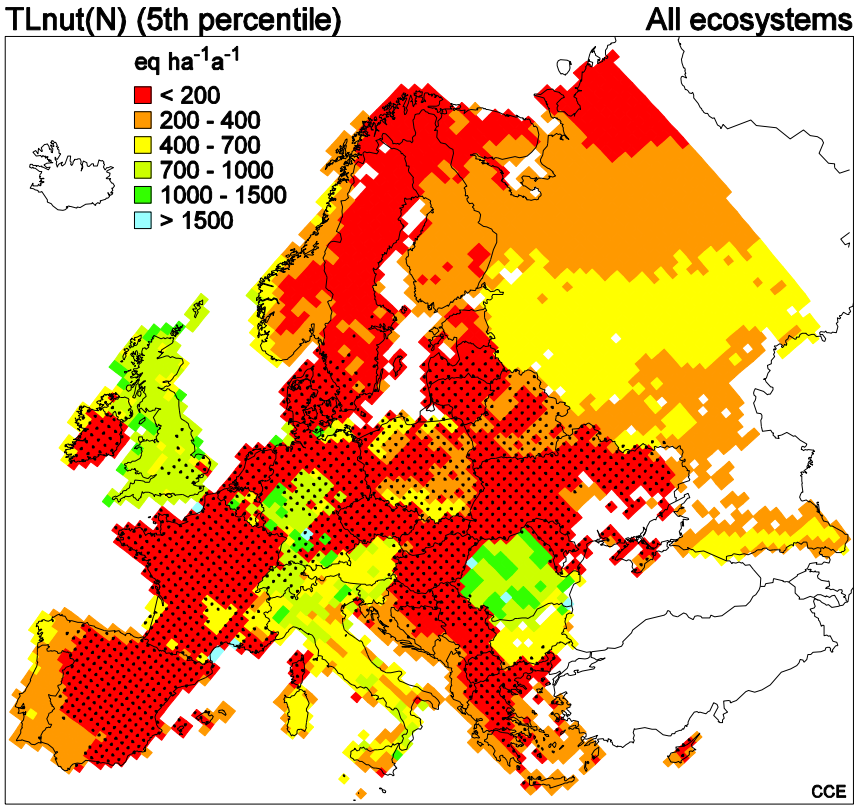
- The European BG-database for modeled critical loads is compiled from, e.g.:
  - Harmonized land cover map (CCE SR 2008) -> *EUNIS; also specifying NATURA 2000 areas*
  - Soil maps from Eurosoil (1999), FAO (1981) -> *transfer function for CEC and B_{sat}, denitrification, N immobilisation*
  - Forest growth map from the European Forest Institute (Schelhaas *et al., 1999)* -> *nutrient uptake*
  - Database on monthly precipitation, temperature and cloudiness (Mitchell, *et al* 2004) -> *precipitation surplus, soil water content*
  - …
- These are overlayed to enable the computation of the critical load for acidification and for eutrophication for each EUNIS class, in each EMEP grid cell,
- Map of $Cl_{nut}(N)$ consists of 3 Mkm^2 NFC-data and 0,7 Mkm^2 BG-data,
- Map of Empirical critical loads consist of 1.5 Mkm^2 NFC-data and 0.6 Mkm^2 BG-data.

Critical (CL) and target loads (TL) of eutrophication

Critical loads



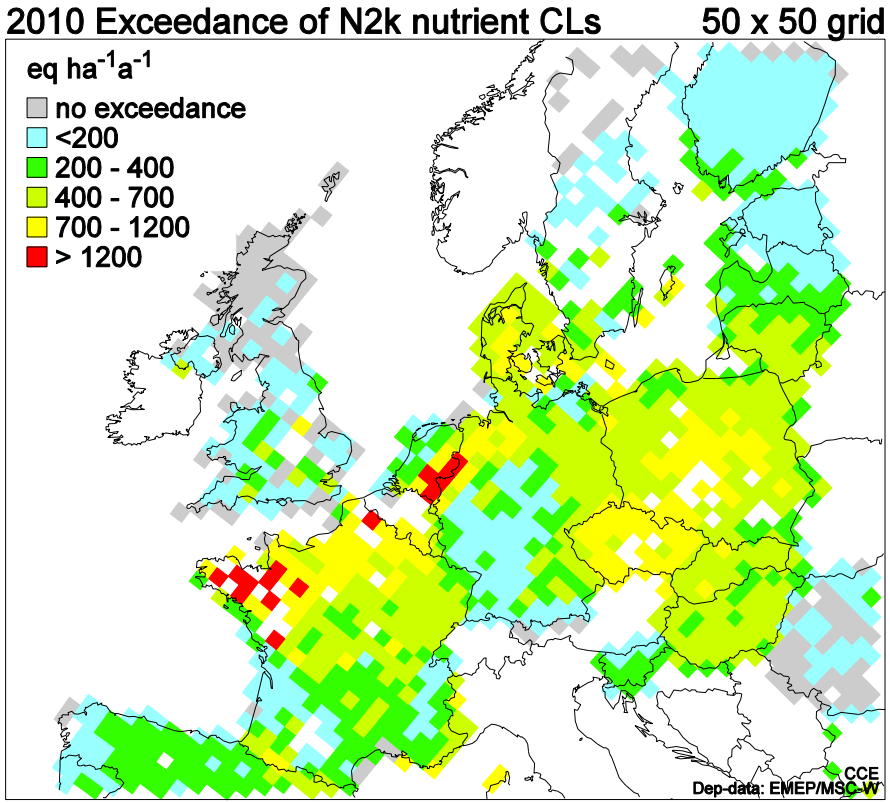
Target loads
i.e., recovery by 2050

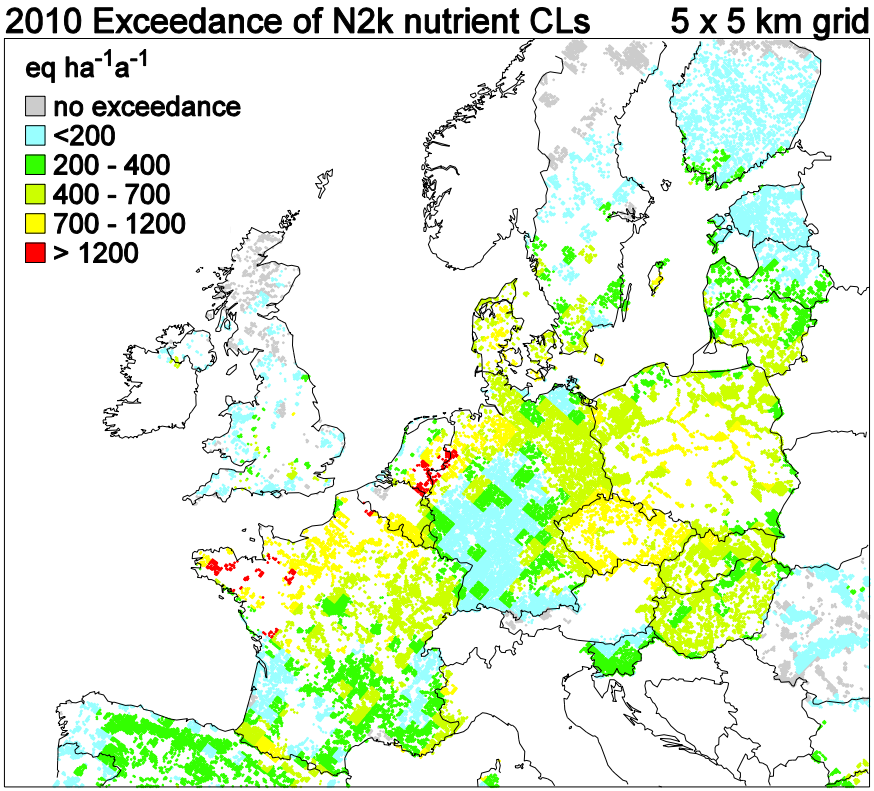


Exceedance of $CL_{nut}(N)$ for NATURA 2000 areas mapped in 50x50 km^2 (left) and 5x5 km^2 (right) grid cells

50 x 50 km grid with N2k areas

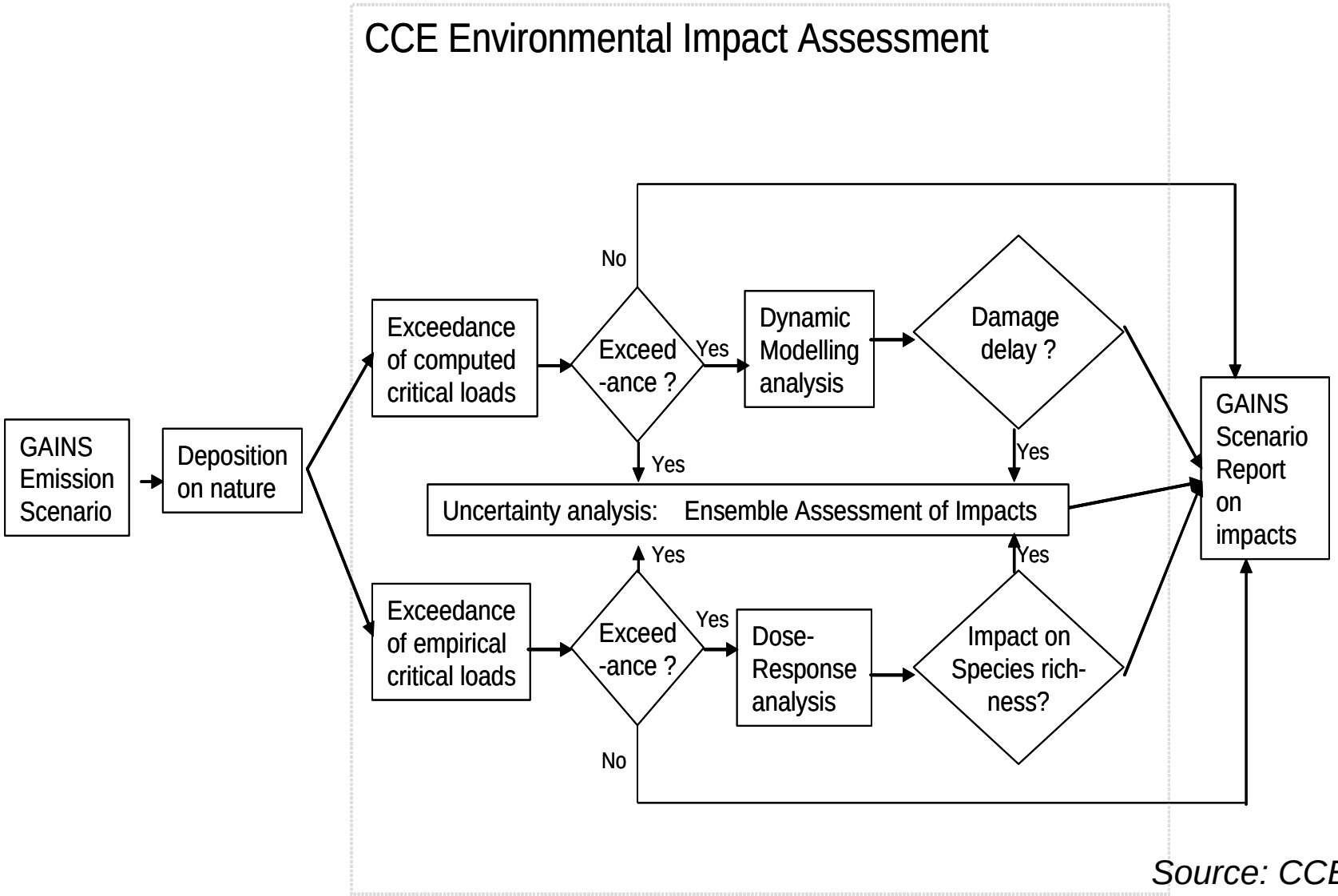
5 x5 km grid with N2k areas





Challenges in the use and development of critical loads

Use in Europe



Source: CCE Status Report 2008

Critical load "Development" benefits

The Effect-based program under the LRTAP Convention in general and the ICP Modelling and Mapping (ICP M&M) in particular:

- Creates a sense of common purpose to improve knowledge on the sensitivity of ecosystems,
- Stimulates steady progress of methodologies and data for the analysis of bio-geochemical as well as biological processes
- Brings together communities that address effects on nature from different perspectives (e.g. …modellers and field-researchers; "good ecological state" and "air pollution effect" experts …)
- Offers a common objective to address issues of scale and aggregation
- Enhances the formation of research groups and consortia for making scientific progress, write papers in the open literature and for acquiring funding
- Has provided and still provides broad material for environmental science education and (many) Ph.D research results ranging from natural sciences to systems analysis.

Critical load "Use" benefits

Collaboration between the ICP M&M and policy support community:

- Expedites the broad scale (temporal and spatial) analysis of possible effects of pollution abatement alternatives
- Stimulates an operational trade off between site specific data requirements for effect assessments and broad scale applications of environmental models and (European) integrated assessment
- Strengthens a common knowledge basis for environmental (air quality) policy
- Improves communication between science and (inter-)national policy
- Helps stake holders with assessments (negotiations…) of emission abatement requirements and trade off.
- Enhances the development of region-specific integrated assessment models
- Strengthens multidisciplinary (applied) research
- Substantiates the relevance of research proposals with comprehensive policy applications

Recommendations regarding the development of critical loads methods and data in the USA

- Available critical load methods that have been applied in Europe, Asia and Canada can also be considered for use in the USA.
- Indicator values and data, especially for critical limits, need to be reviewed and possibly revised for applications tailored to natural areas in the U.S.A.…
- …However, data collection is not necessarily required for all natural systems; in a first step, focus improvements of critical loads input data on those areas where depositions are likely to exceed critical loads, the latter being established with, e.g. 'fail-safe' (critical limits,
- The CCE is anxious to extend the work of the ICP M&M to include U.S.A. Focal Centre operatives !

Thank you for your attention !

Further information:

- LRTAP Convention, Working Group on Effects (WGE): www.unece.org/env/lrtap/WorkingGroups/wge/welcome.html
- ICP Modelling and Mapping (manual): www.icpmapping.org
- CCE: www.pbl.nl/cce