Past, Present and Future of Critical Loads – European Perspective

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Thanks to Jean-Paul Hettelingh and other colleagues at former CCE

History of Critical Loads (CLs) Concept (1):

1983: Canadian WG on Impact Assessment proposed a "target load" of 20 kg/ha/yr of wet sulphate deposition to aquatic ecosystems. **CA**

1986: Report of a Nordic Working Group provides first estimates of CLs of S and N (Nilsson 1986) **NMR**

Example of CLs:

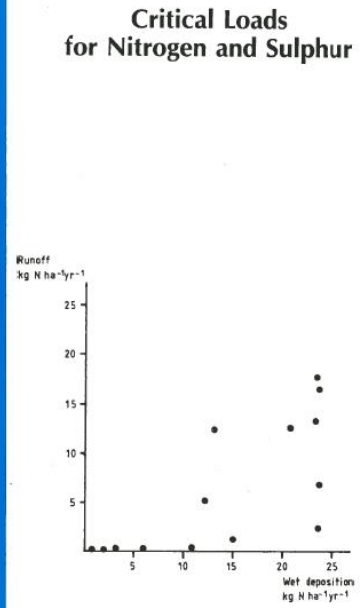


Table 1. Critical acid loads, at which in most soils there will be no decrease of pH or mobilization of inorganic cations (such as aluminium) in the soil solution of the rooting zone. Data in the references have been recalculated according to Nilsson (1986).

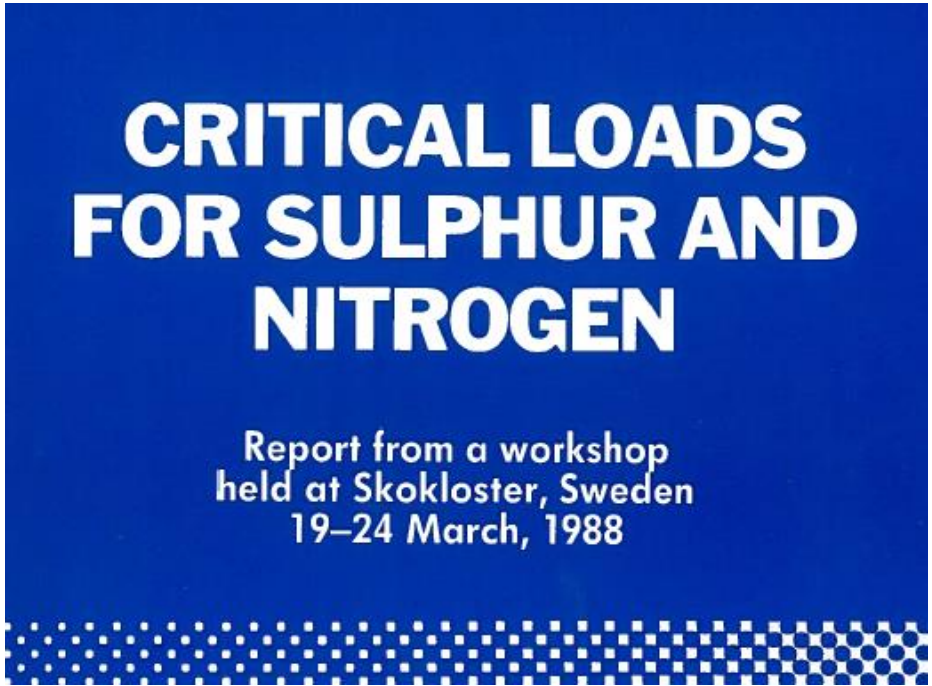
Reference	H^+ keq·km^{-2}·yr^{-1}	Area
Nilsson (1986)		
- median	20	Scandinavia
- range	0-75	Scandinavia
Aberg (1986)	20-30	Scandinavia
Fölster (1985) and Matzner (pers,comm)	0-60	FRG
Van Breemen (1986)	25	The Netherlands
Mulder (pers.comm)	0	The Netherlands
Paces (1985)	50-70	Czecho-Slovakia
de Vries et al (1986)	2-20	The Netherlands
Johnson et al (1985) (sulphate adsorption/ desorption included)	50-280	USA

NADP,

History of Critical Loads Concept (2):

1988: NMR/**UNECE** WS in Skokloster (SE) comes up with the still valid **definition** of a CL (Nilsson and Grennfelt 1988):

"… the quantitative estimate of (a)
an exposure to one or more pollutants (b)
below which significant harmful effects (c)
on specified sensitive elements of the environment (d)
do not occur according to present knowledge." (e)



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History of Critical Loads Concept (3):

1992: WS on Nitrogen CLs in Lökeberg (Sweden)
(Grennfelt & Thörnelöf 1992)
…. elaborated present formulation of nitrogen CLs.

Furthermore:
- 1994: Grange-over-Sands (England) …
- 1999: Copenhagen (stock-taking …)

Also:
- many workshops on CLs of Heavy Metals
- many workshops on critical levels/fluxes of Ozone
- (updates of) empirical CLs (for N)
(Berne, 2002; Noordwijkerhout 2010)

Here only CLs of acidity (S) and N …

History of Critical Loads Concept (4):

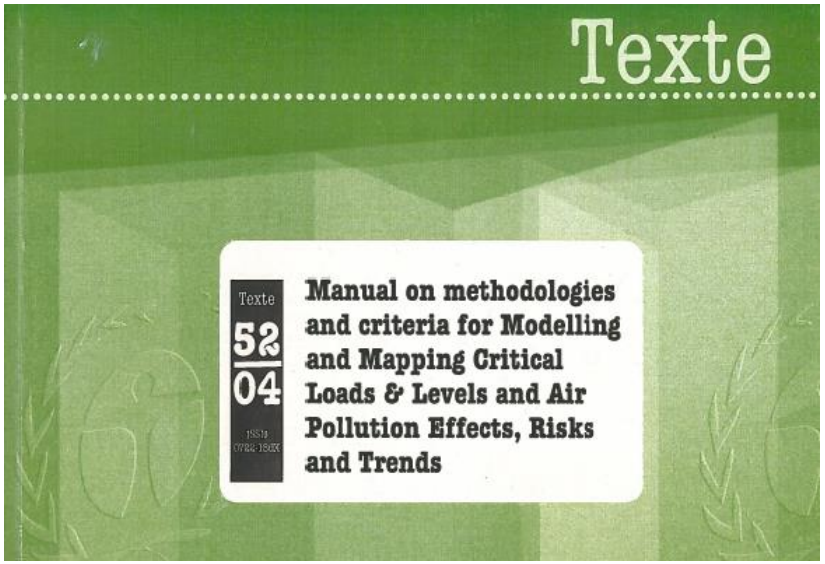
Working Group on Effects (WGE) of LRTAP Convention took over concept (1988) …

1989: UNECE Workshop in Bad Harzburg (Germany) organised by 'Task Force on Mapping Critical Levels/Loads'

By 9 November we had:
(1) First Draft of a 'Mapping Manual' [site to region]
and
(2) Opening ('Fall') of the Berlin Wall

Methodology/Science (1)

Mapping Manual describes methods:
(a) to calculate a CL for a 'site'
(b) to compute exceedances
(c) to derive statistics and map CLs
… now updated at www.icpmapping.org



2004

A. **CL of nutrient N**:
Starting point: steady-state mass balance of N in soil:

$$N_{dep} = N_{upt}+N_{imm}+N_{den}+N_{le}$$

Select critical limit for N_{le} to protect/avoid … and insert:

$$CL_{nut}(N) = N_{upt}+N_{imm}+N_{den}+N_{le,crit}$$

Important: steady state! i.e. no change in pools, etc.
… otherwise we are at dynamic modelling!

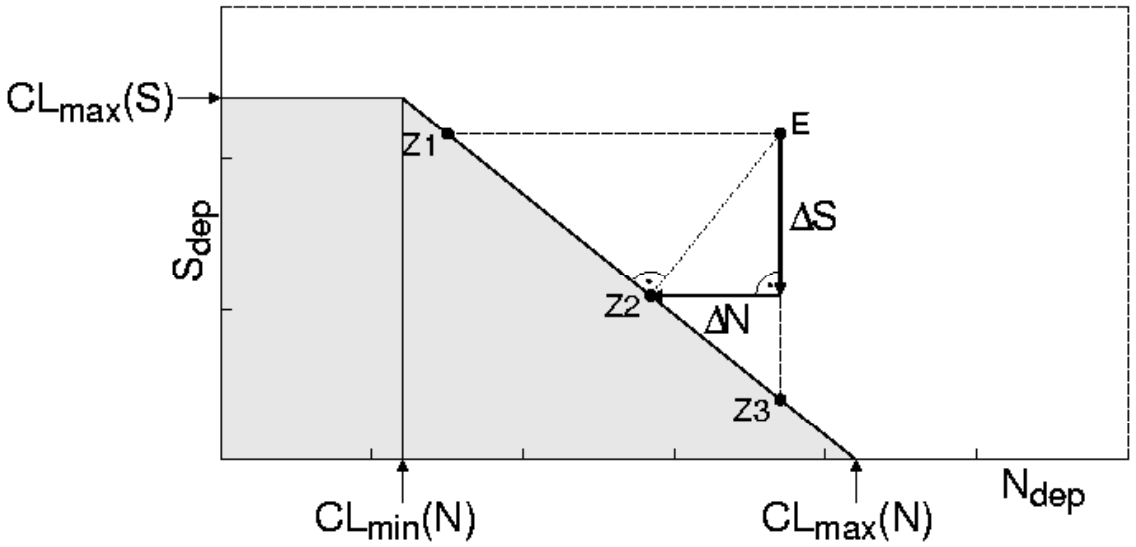
Methodology/Science (2)

B. **CLs of (N and S) acidity:**

Mass balances of N, S, BCs, charge balance in (soil) solution, selection of chemical criterion, e.g. $(Al/Bc)_{crit}$, $[ANC]_{crit}$, to protect …

… no unique CL, but CL-function characterised by 3 numbers:

$CL_{max}S$, $CL_{min}N$, $CL_{max}N$



Took some time to stablish; too 'complicated'?. etc …

Methodology/Science (3)

C. **Comparison to Depositions - Exceedances:**

→ link to emission reduction policies!!

a) CLnut: $Ex = N_{dep} - CL_{nut}N$

… easy … single number (set to zero if <0)

b) Claci: No unique exceedance ➔

Exceedance ***defined*** (see above)

Several other methods used in earlier stages …

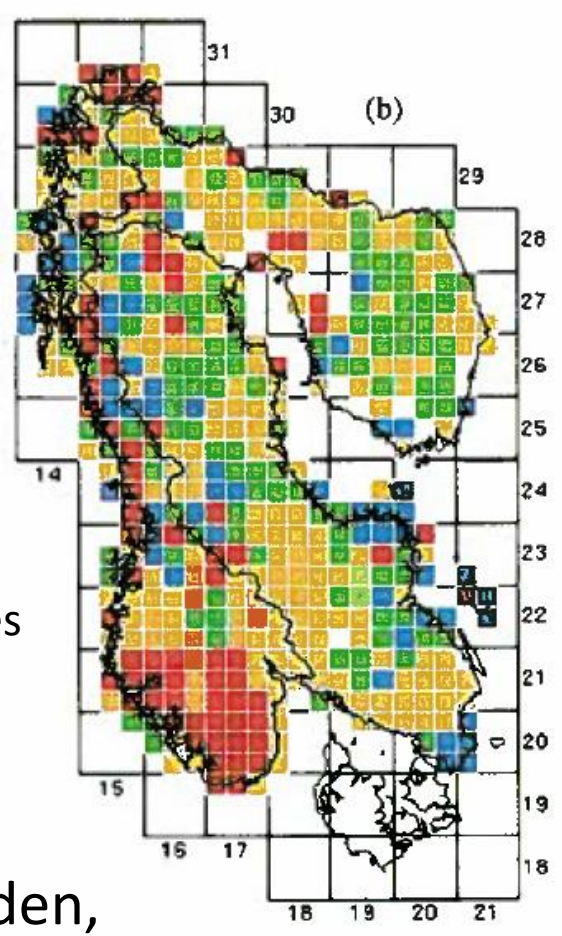
Note: Exceedances time-dependent!

Early regional computation and mapping of CLs of sulphur (acidity) for ***surface waters***:

Critical Loads to Surface Waters in Fennoscandia

Intra- and Inter-grid Variability of Critical Loads and their Exceedance

Henriksen et al. (1990)



25-th percentile of CL(S) for lakes in Fennoscandia (150×150 grid)

But also acidity CLs for (forest) ***soils*** in Sweden, with emphasis on BC weathering ….
H. Sverdrup, *P. Warfvinge*, et al.
… and the NL *(De Vries* et al., ….)

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In 1990-ies:

Coordination Centre for Effects (CCE) founded in 1990

- under the LRTAP ICP on Modelling & Mapping
- financed by the NL and led by *Jean-Paul Hettelingh*

Main Tasks:

- Provide European maps of critical loads
- Further develop methodology, supported by individual scientists (e.g., *Harald Sverdrup* et al., *Wim de Vries* et al., …)
- …

Carried out by:

- Asking countries for national CLs (via 'Calls for Data')
- Filling gaps by 'own' European Background Database
- …

… CLs had reached the European policy arena …

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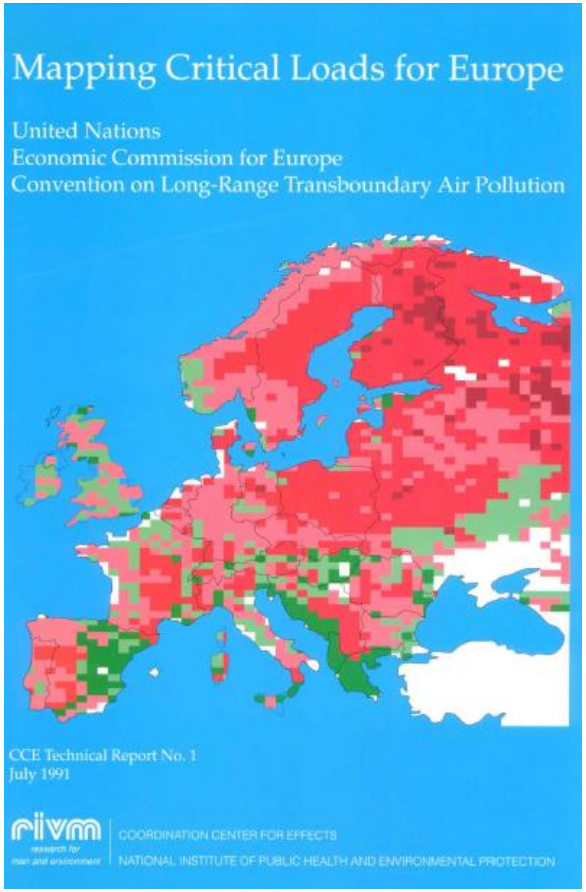
European Critical Loads (and related issues) reported to Working Group on Effcets (WGE), Executive Body of LRTAP Convention and documented in CCE Reports …



1991

…….

2017

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Policy Use of Critical Loads:

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 by choosing an equal percentage emission reduction for all countries involved.
WGAS Report EB.AIR/WG.5/R.24/Rev.1 (**1991**)

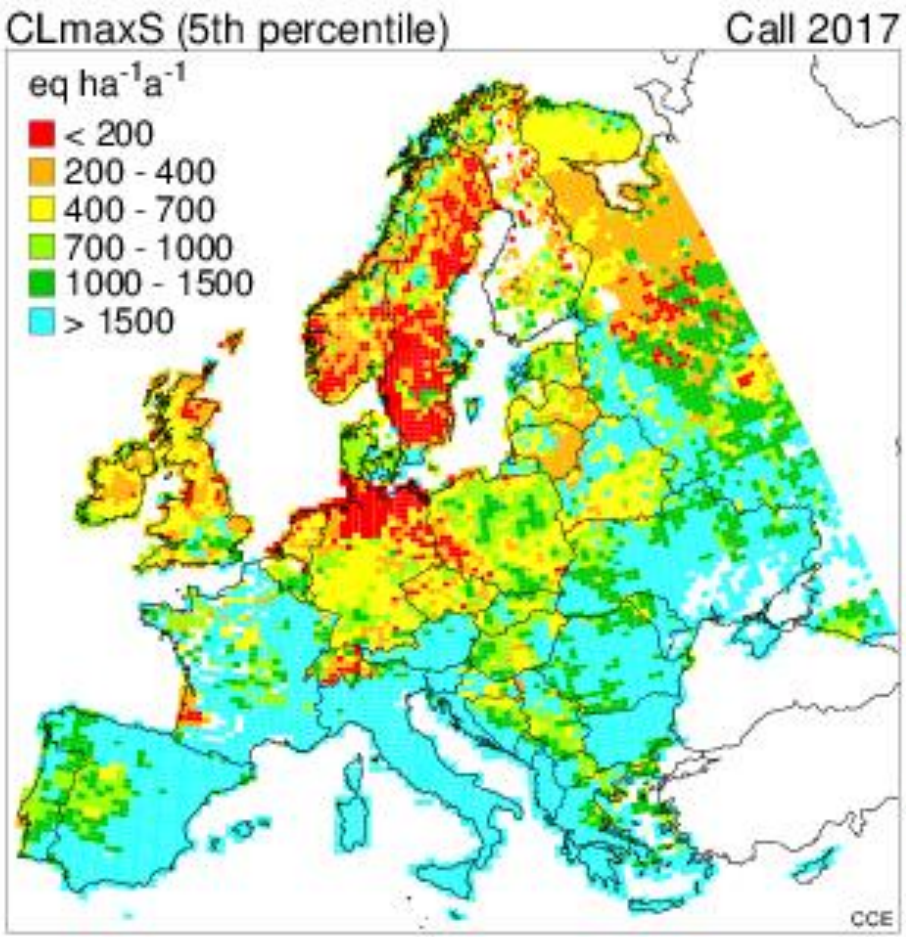
CLs have been used in the preparation/negotiations of the

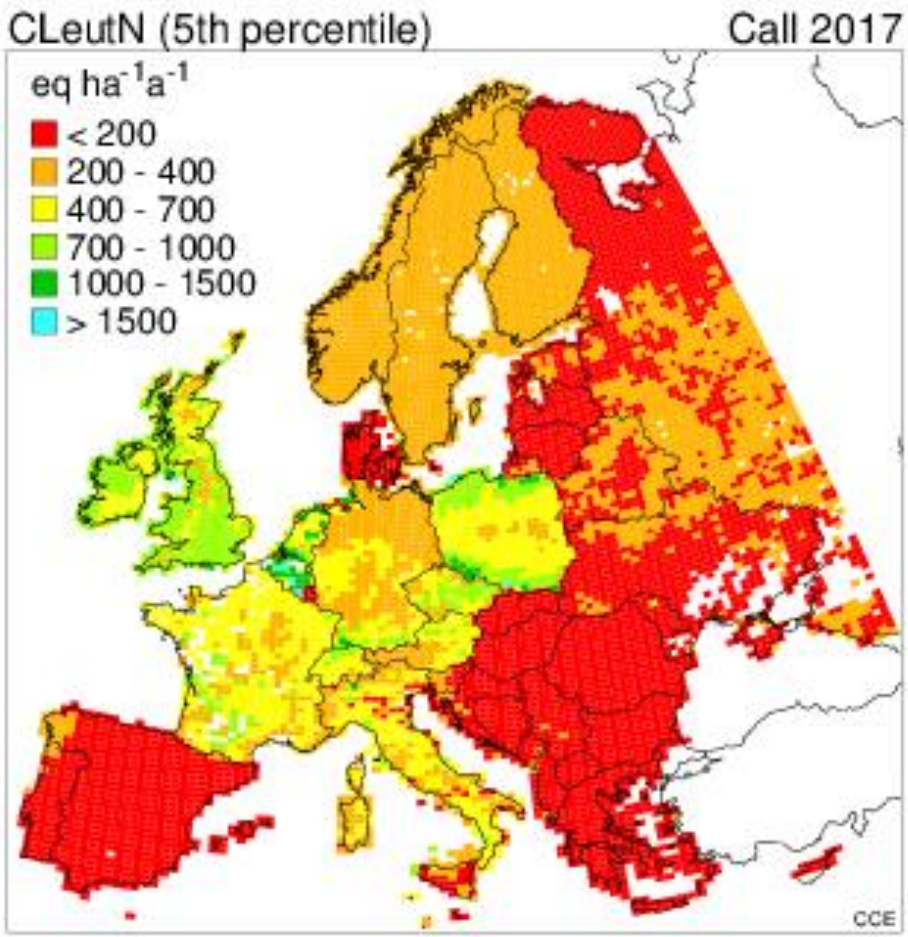
- 1994 Second Sulphur Protocol to the LRTAP Convention
- 1999 Protocol on Abate Acidification, Eutrophication and Ground-level Ozone ("Gothenburg Protocol")
- 2001 EU National Emission Ceiling (NEC) Directive

… and their various updates …

Also, several countries use(d) them to formulate policies/regulations on a national/regional scale.

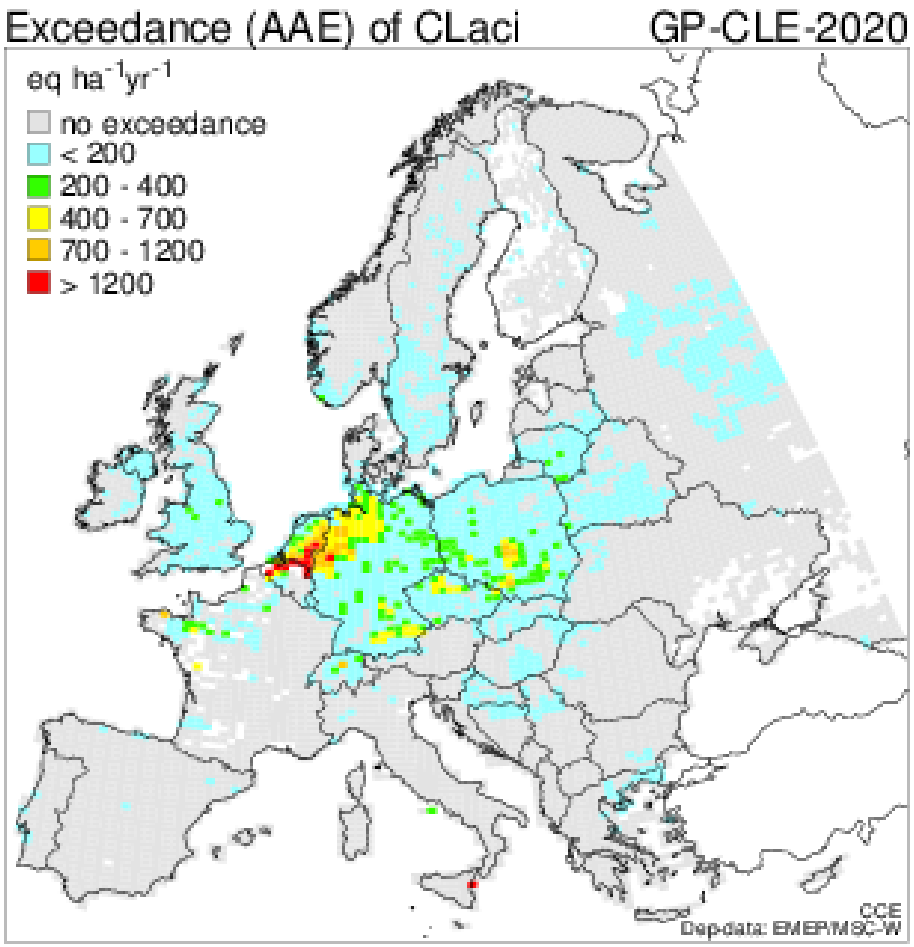
5-th percentiles of 2017 CLmaxS (left) and CLeutN (right)

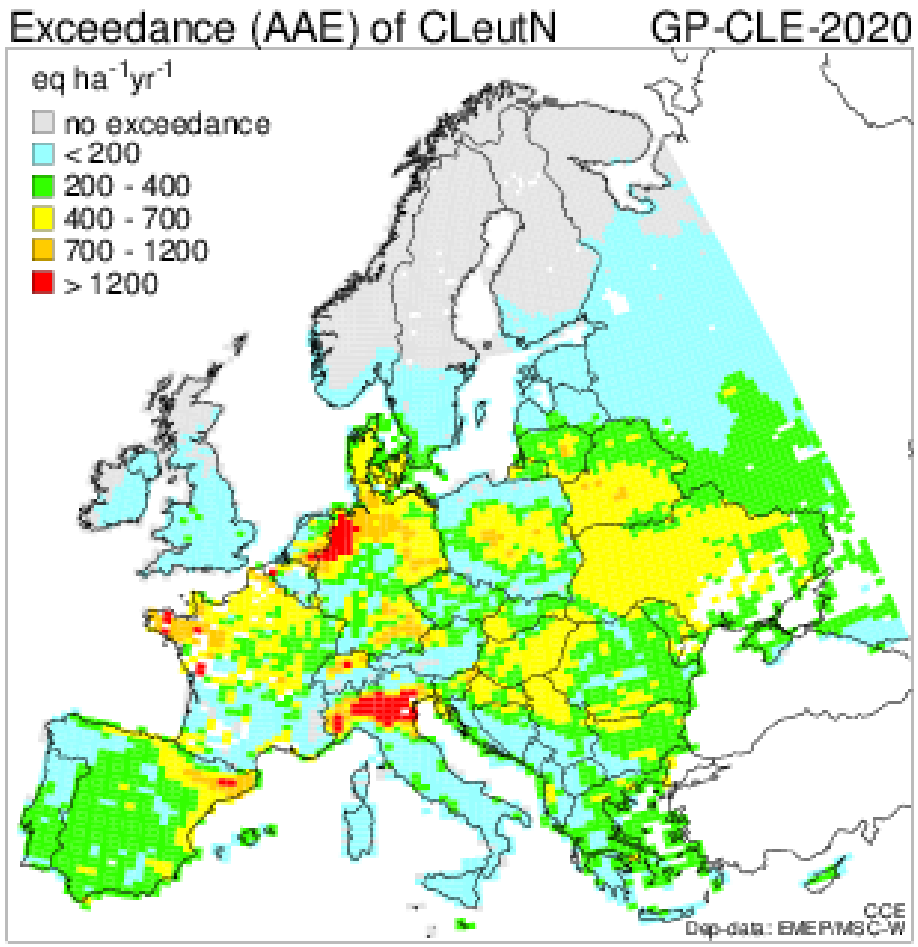




… protects 95 % of the ecosystems in a grid cell

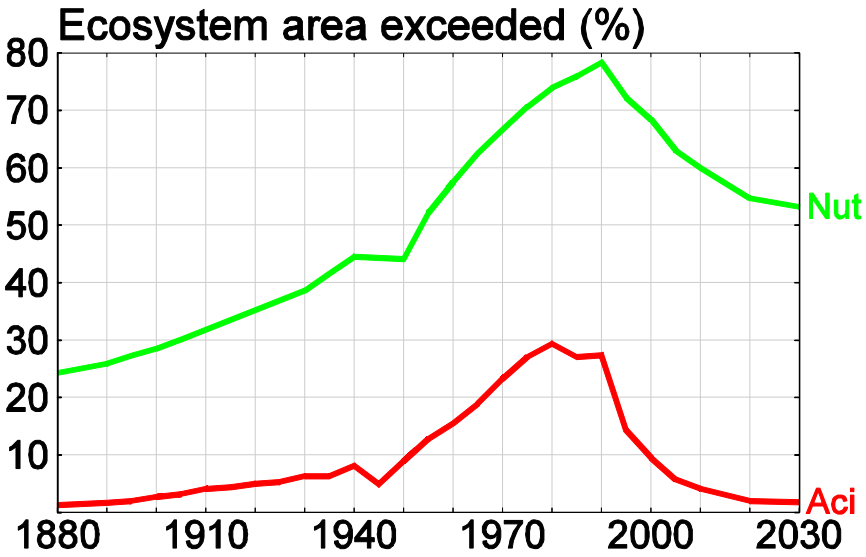
2020 exceedance of acidity CLs (left) and CLeutN (right)

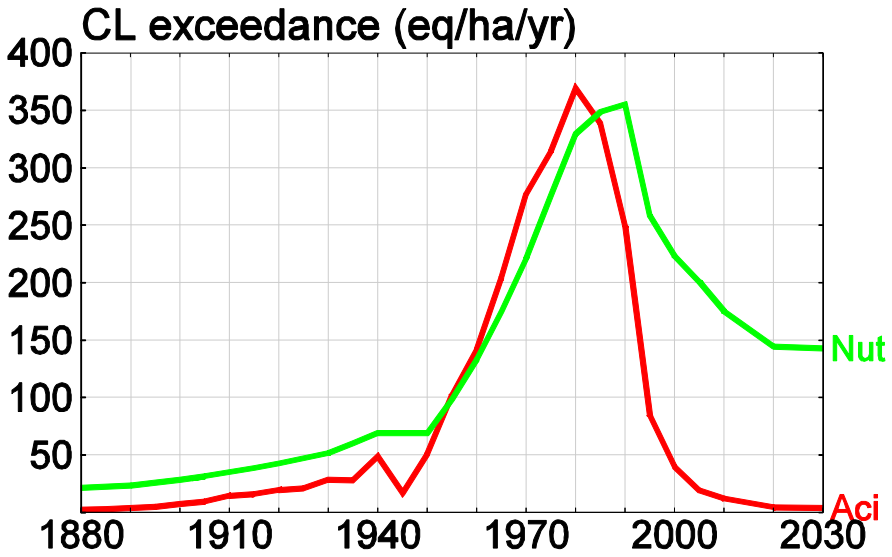




Different maps for every deposition (year) …

Trends of CL exceedances since 1880





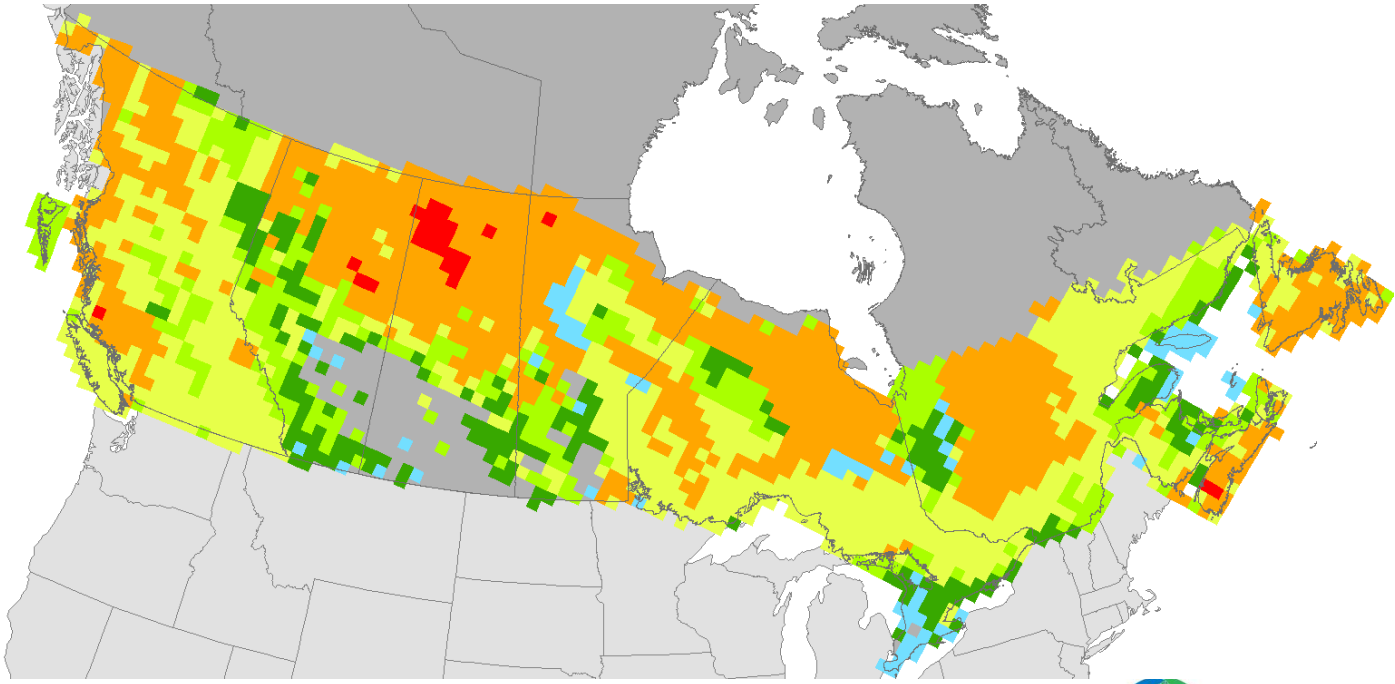
Area exceeded of acidity and nutrient N CLs

Exceedance of CLs of acidity and nutrient N

… and this says it 'all' …

CLs outside Europe

- Canada
- United States of America
- China
- South Africa
- (sub-)Arctic (AMAP)
- Global



Future of CLs

- *Biodiversity CLs* developed over recent years (but not yet 'used')
- Dutch government stopped funding CCE by end of 2017
- German Environment Agency (UBA) took over CCE role

  Currently transfer of data and know-how ...
- Latest CLs still available for integrated assessment (at CIAM/IIASA)
- CLs 'regularly' used by European Union
- … and in some national assessments
- Interest in CLs in some other regions still growing

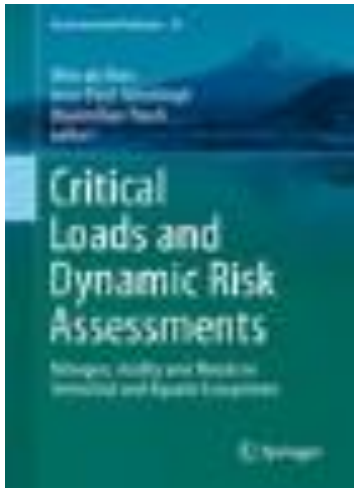
Important:

- International cooperation/network is essential,
  both for scientific diversity and general acceptance
- It's easy to dismantle an international network, but difficult to build up again (loss of knowledge/experience)

Thank you for your attention!

If you really want to know more about Critical Loads:

De Vries W, Hettelingh J-P, Posch M (eds), 2015.
Critical Loads and Dynamic Risk Assessments: Nitrogen, Acidity and Metals in Terrestrial and Aquatic Ecosystems.
Environmental Pollution Series Vol. 25, Springer, Dordrecht, xxviii+662 pp.
DOI: 10.1007/978-94-017-9508-1



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