Modelling critical loads of nitrogen, exceedances and dynamic ecosystem effects

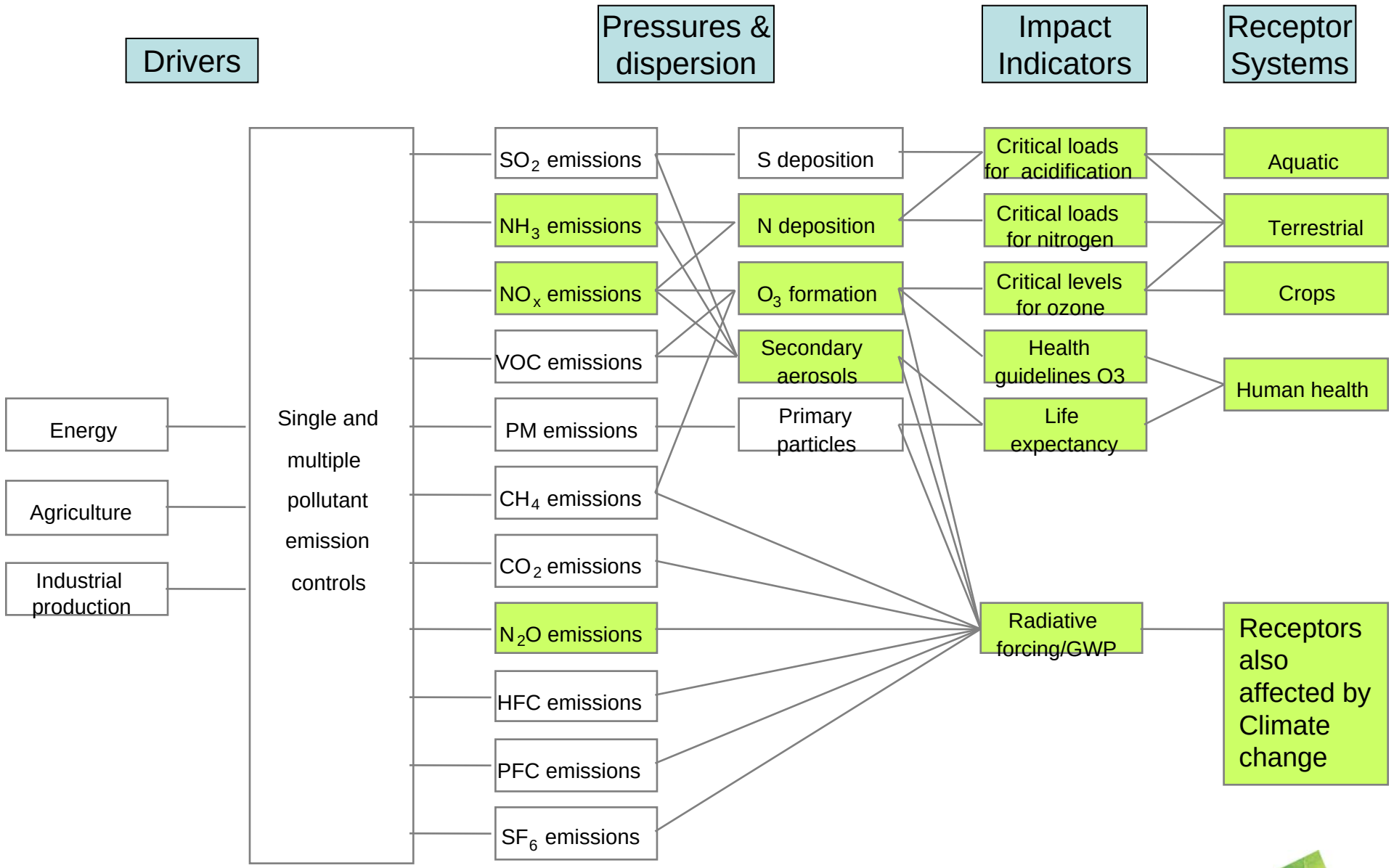
Source: CCE Progress Report 2007

J. Slootweg, M. Posch, J.-P. Hettelingh (eds).
www.mnp.nl/cce

Acknowledgements:

- Directorate for Climate Change and Industry of the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM),
- the European Commission LIFE+ programme for funding the “European Consortium for Modelling Air Pollution and Climate Strategies (EC4MACS),
- the Working Group on Effects account within the trust fund for the partial funding of effect-oriented activities under the Convention on Long-range Transboundary Air Pollution (LRTAP Convention)

Multi-pollutant Multi-effect relationships under the LRTAP Convention and EC Thematic Strategy on Air Pollution



N-Effect based program under LRTAP Convention

Includes a focus on:

- Effects of N deposition on biodiversity

Inter alia, by developing methods and databases to:

- Assess Critical loads of nitrogen, CL(N),
- Assess exceedances of CL(N) as measure of risk,
- Assess future N-effects with Dynamic Modelling.

…which are the 3 subjects of this presentation !

Critical loads of nitrogen

Based on results of the 2006-2007 call for voluntary data to National Focal Centres (NFCs) of Parties under the Convention and EC-Member States by the Coordination Centre for Effects (CCE)

"Voluntary" to give scientific and technical leeway for NFCs to…:

- …test new knowledge, *not yet for use* in RAINS/GAINS,
- …update critical limits in simple mass balance calculations,
- …tentatively apply empirical critical loads (Achermann and Bobbink, 2003) with focus on:
  - (i) those EUNIS classes for which NFCs provided computed critical loads
  - (ii) Natura 2000 (N2K) areas,
- …explore NFC applications of dynamic modelling of eutrophication, using VSD or more complex models.

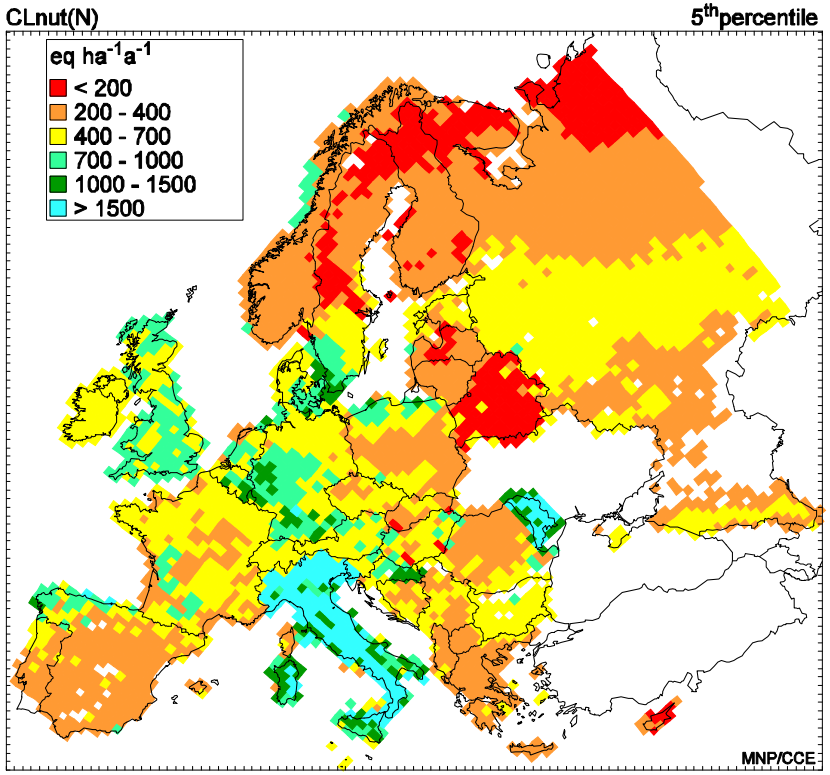
Results of call for voluntary data

Country code	Country	Modelled critical loads of sulphur and nitrogen	Empirical critical loads of nitrogen	Critical loads for N2K areas	Dynamic modelling
AT	Austria	X	X	X	X
BE	Belgium	X	-		X
BG	Bulgaria	X	X	X	-
BY	Belarus	X	-		-
CA	Canada	X	-		X
CH	Switzerland	X	X		X
CZ	Czech Republic	-	X	X	-
DE	Germany	X	X	X	X
FR	France	X	X	X	X
GB	United Kingdom	X	X	X	X
IE	Ireland	X	X		-
IT	Italy	X	-		-
LT	Lithuania	X	-		-
NL	Netherlands	X	X		X
NO	Norway	X	X		X
PL	Poland	X	X	X	X
SE	Sweden	X	-		X
SI	Slovenia	-	X	X	-
UA	Ukraine	X	-		-
Total	19	17	12	8	11
EC-MS	14	12	10	8	8

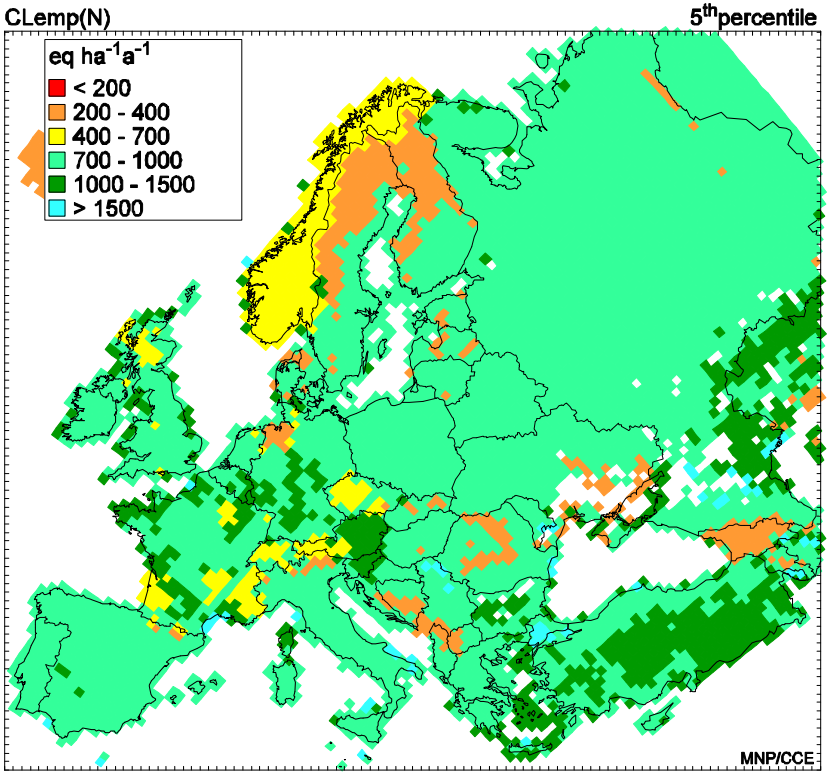
Results of call for voluntary data, Cont^{d}...

Including CCE background data for countries that did not submit data !

5th percentile (modelled) critical loads of nitrogen: $CL_{nut}(N)$



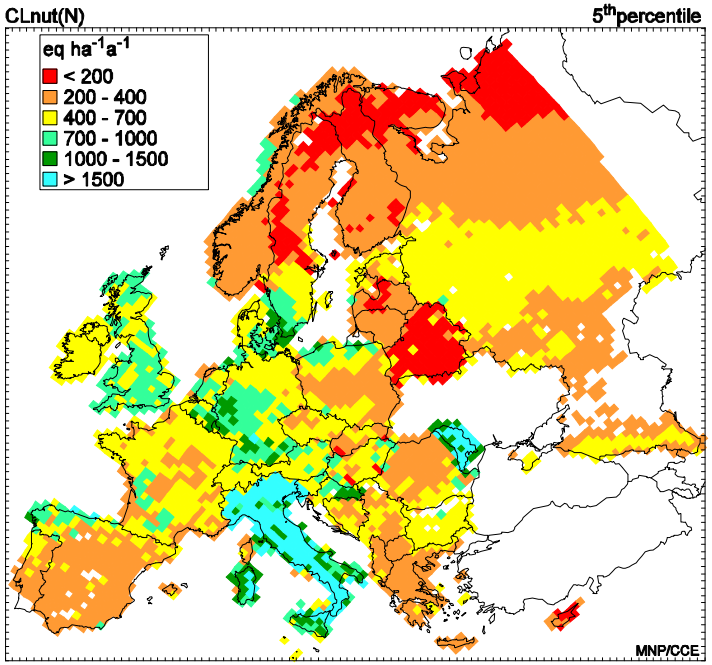
5th percentile (expert-based) empirical critical loads of nitrogen: $CL_{emp}(N)$



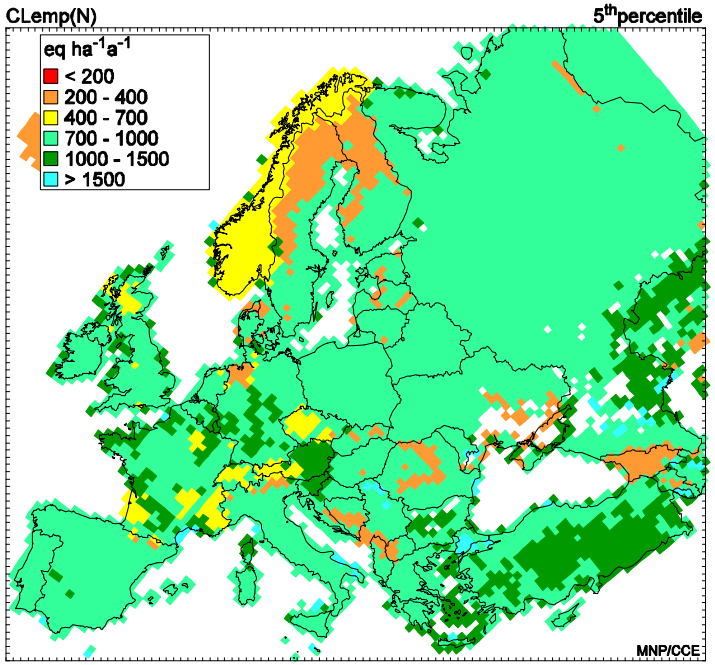
Results of call for voluntary data, Cont^{d}…

Including CCE background data for countries that did not submit data

- Modelled critical loads tend to be lower than empirical C-loads
- Empirical critical loads that are lower than 200 eq $ha^{-1}a^{-1}$do not occur
- Both types of critical loads are low in Northern Europe
- 700 < $CL_{emp}(N)$ < 1000 covers a broad area
- 200 < $CL_{nut}(N)$ < 700 covers a broad area



$CL_{nut}(N)$



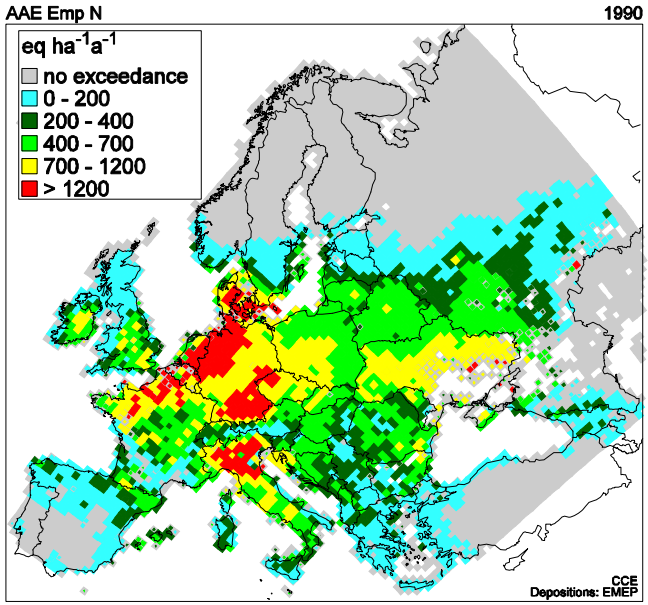
$CL_{emp}(N)$

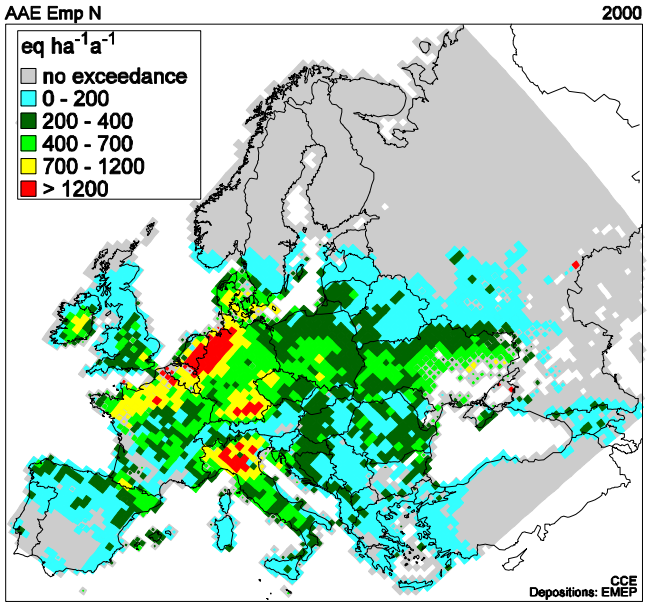
Exceedances

Trend of exceedances (AAE) of $CL_{emp}(N)$,

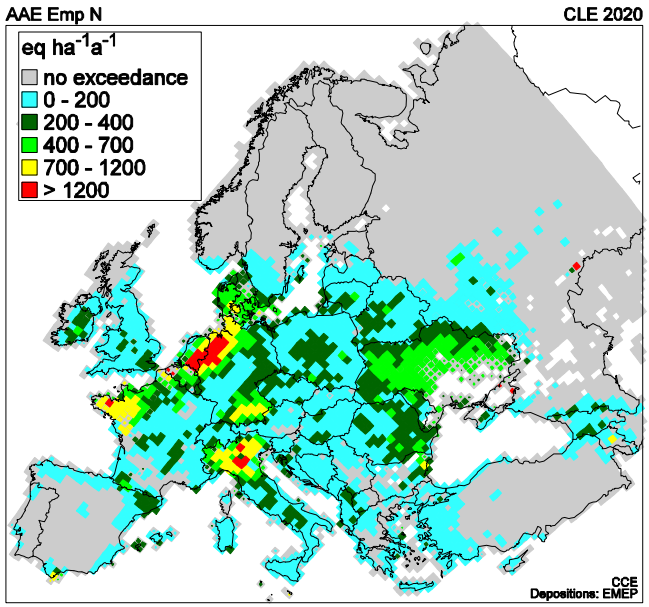
2020 following Current Legislation (CLE) and Maximum Feasible Reductions (MFR) (source:IIASA)

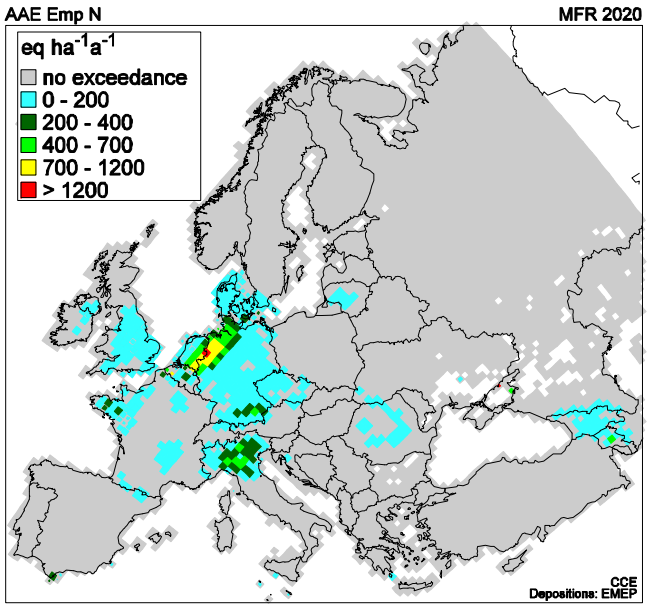
1990





2000





CLE 2020

Protected:
EU27: 61%
LRTAP: 79%

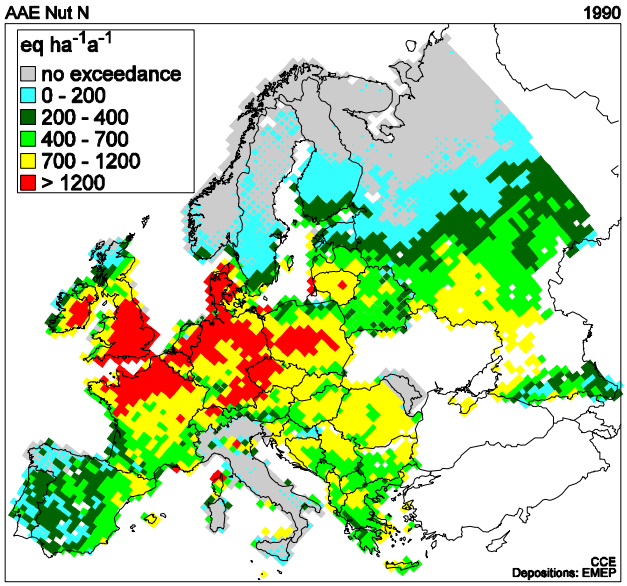
MFR 2020:

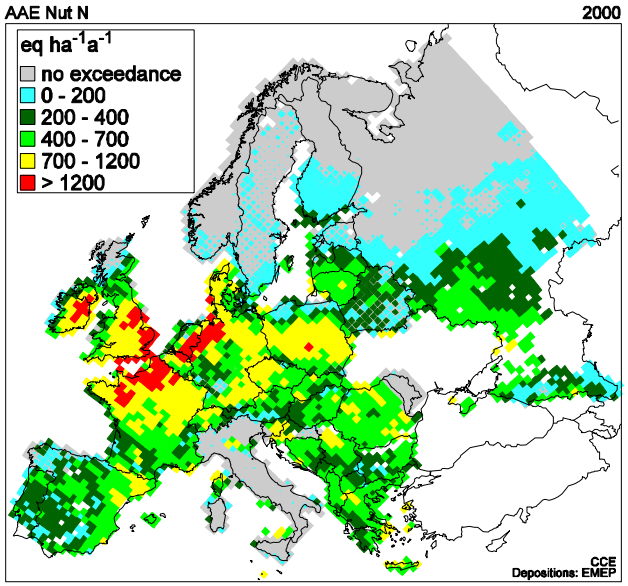
Protected:
EU27: 94%
LRTAP: 98%

Trend of exceedances (AAE) of $CL_{nut}(N)$,

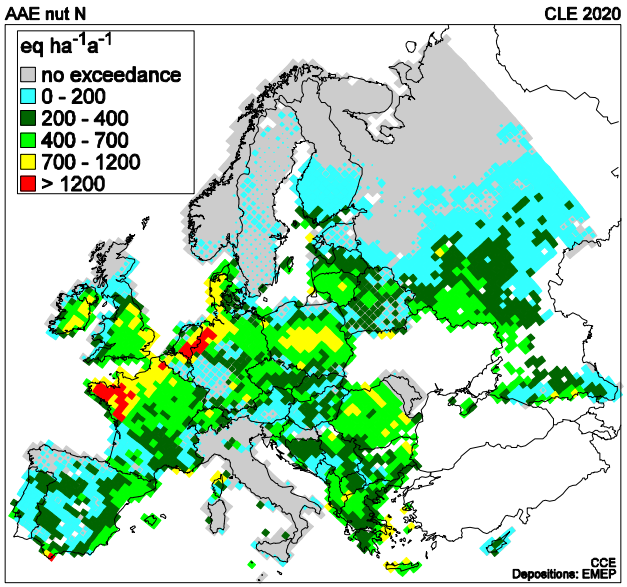
2020 following Current Legislation (CLE) and Maximum Feasible Reductions (MFR) (source:IIASA)

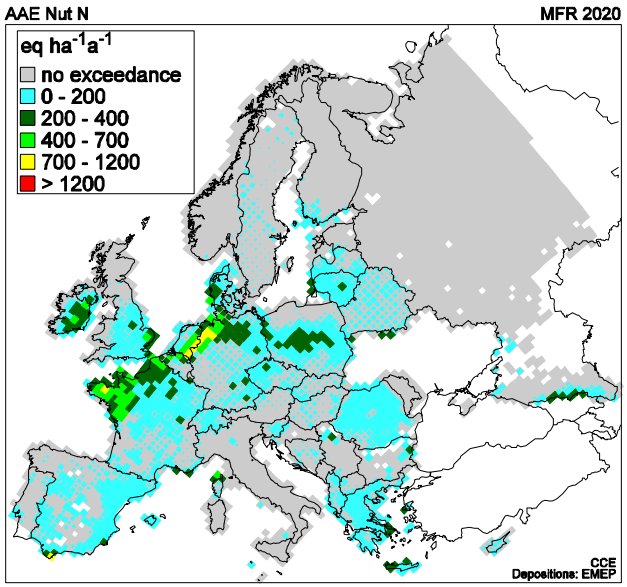
1990





2000





CLE 2020

Protected:
EU27: 42%
LRTAP: 58%

MFR 2020:

Protected:
EU27: 76 %
LRTAP: 90%

What is the likelihood of exceedances ?

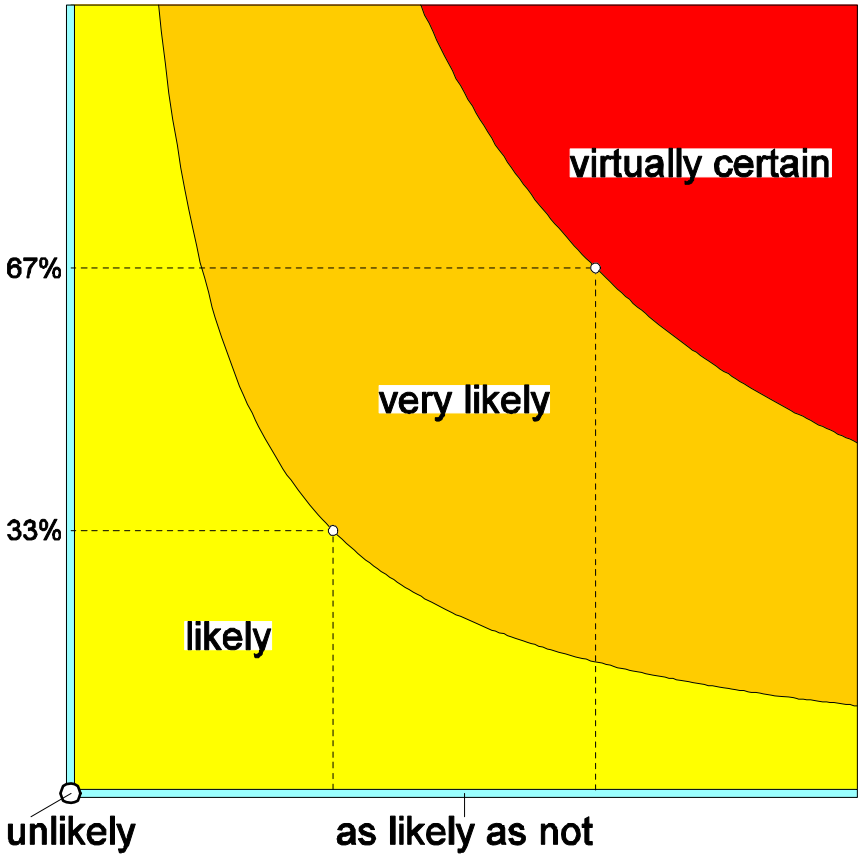
The "*Ensemble Assessment of Impacts (EAI)*" method using exceedances of both $CL_{nut}(N)$ & $CL_{emp}(N)$

(see CCE Progress Report 2007)

Similar to an approach proposed by the FCCC-IPCC in guidance notes for lead authors of the IPCC Fourth Assessment Report on addressing uncertainties

http://ipcc-wg1.ucar.edu/wg1/Report/AR4_UncertaintyGuidanceNote.pdf

The likelihood of an exceedance, i.e. AAE > 0

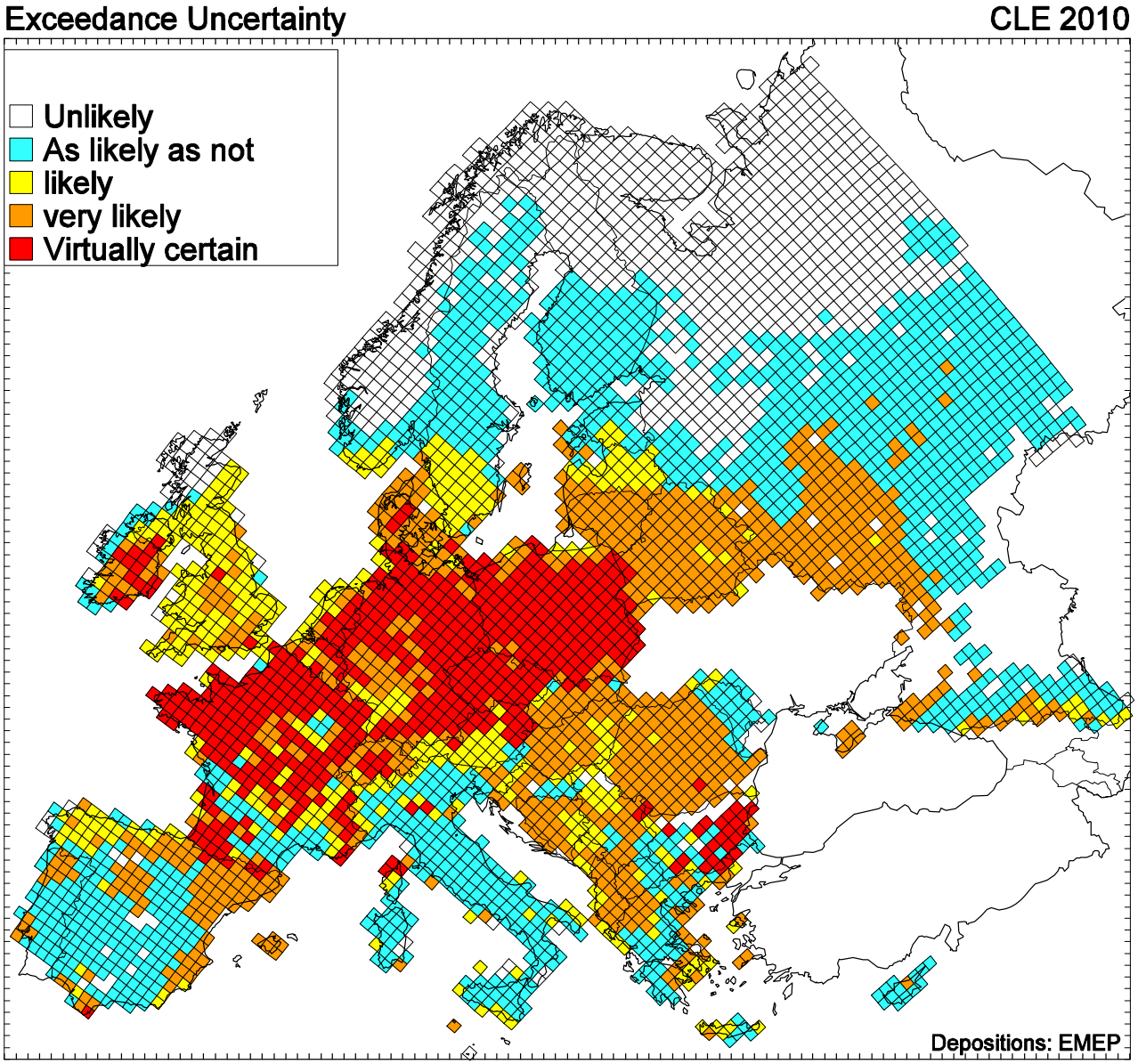


If the square root of % exceedances of $CL_{emp}(N)$ and of $CL_{nut}(N)$ is:

0-33%: exceedance is likely
33-67%: exceedance is very likely
67-100%: exceedance is virtually certain

Source: Hettelingh *et al.* in CCE Progress Report 2007, p. 53-58.

Tentative result of the exceedance likelihood



The likelihood of exceedance computed from the % area where both $CL_{emp}(N)$ and $CL_{nut}(N)$ are exceeded.

Source: Hettelingh *et al.* in CCE Progress Report 2007, pp. 53-58.

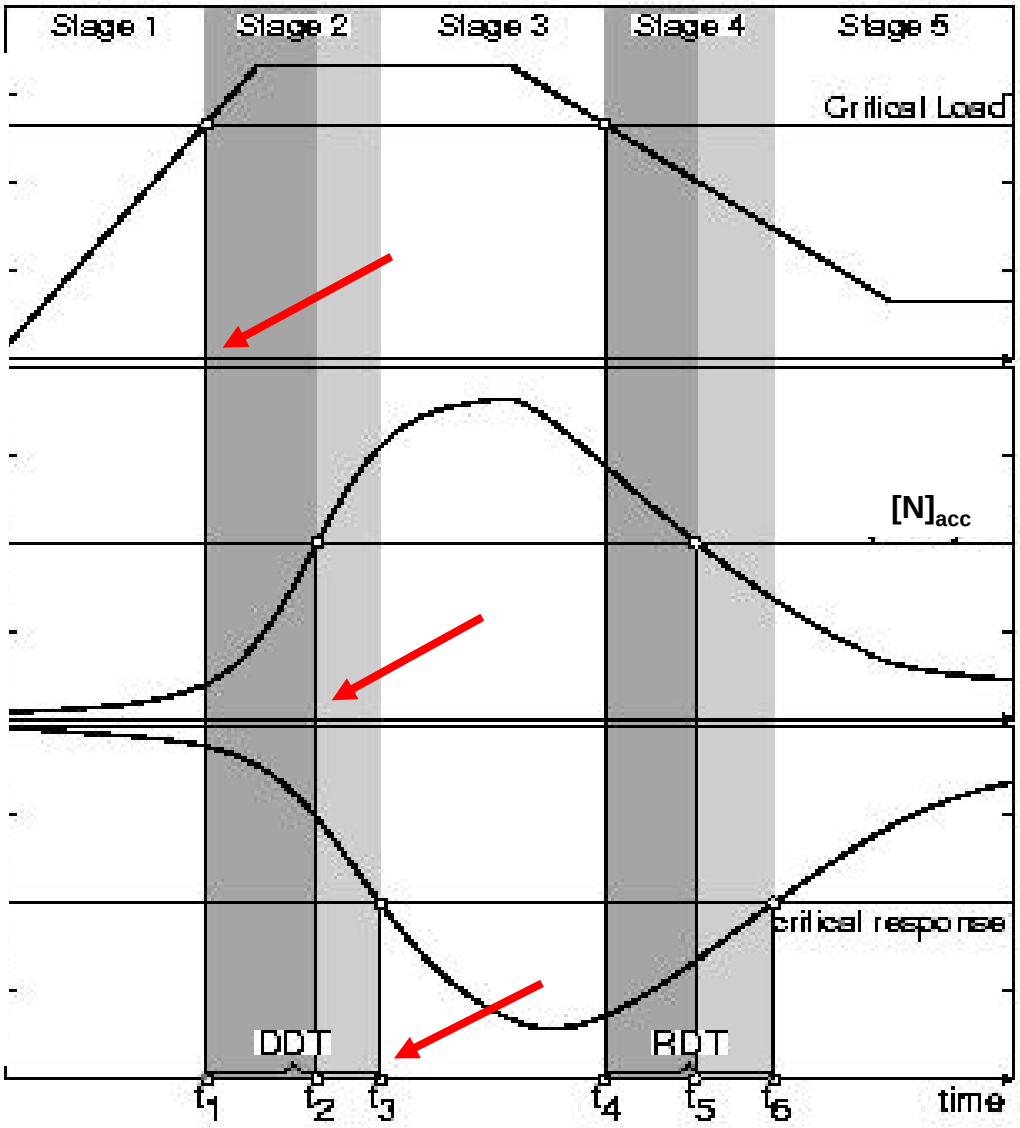
Dynamic modelling: Assessing future ecosystem effects, when *modelled* critical loads are exceeded…

Illustration of VSD application on the CCE background database subject to deposition scenarios, CLE and MFR

(Source: Posch et al., in CCE Progress Report 2007, pp.41-51)

exceedance:

Delay times of damage!



t_1 = Critical Load exceedance

t_2 = Violation chemistry

t_3 = Biological damage

4 combination of critical load CL_{nut}- exceedance (Y/N) and chemical criterion $[N]_{acc}$-violation (Y/N)

If at a given point in time …

Eutrophication

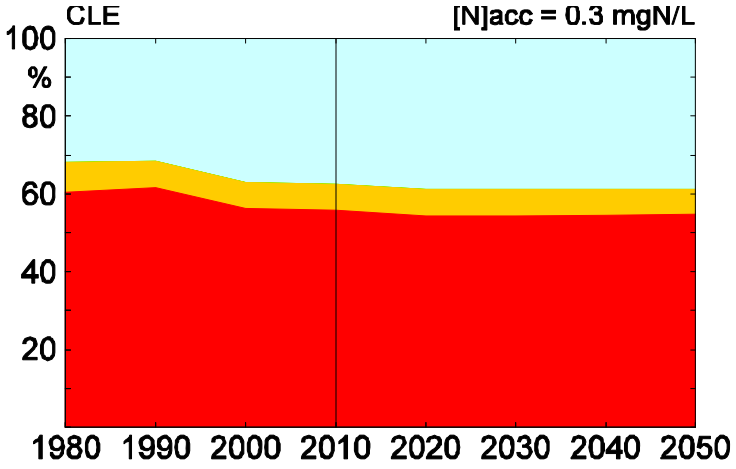
Critical Load (CL) is …

Chemical criterion is …	**Not** exceeded	Exceeded
Not violated	All fine! (1)	**DDT exists:** Reduction to CL within DDT avoids violation (3)
Violated	Hardly occurring, as concentration reacts fast (2)	No meaningful Target Load; but reduction to CL reverses violation quickly! (4)

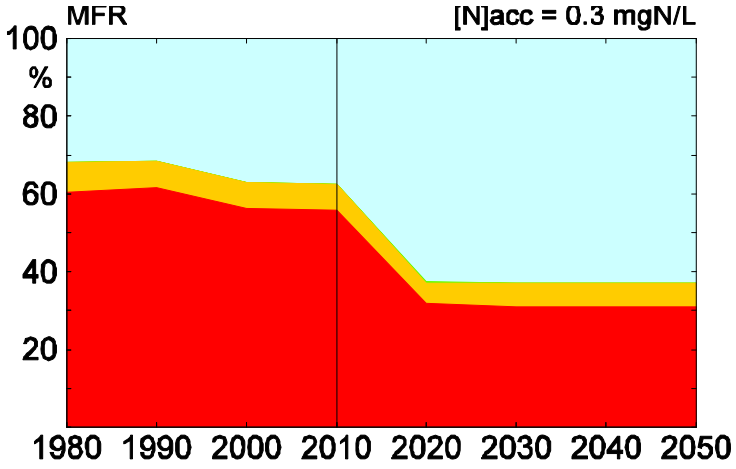
DDT: Damage Delay Time

Illustration of response times of the VSD model with the CCE background database, subject to CLE and MFR deposition scenarios, and applied to low and high $CL_{nut}(N)$.

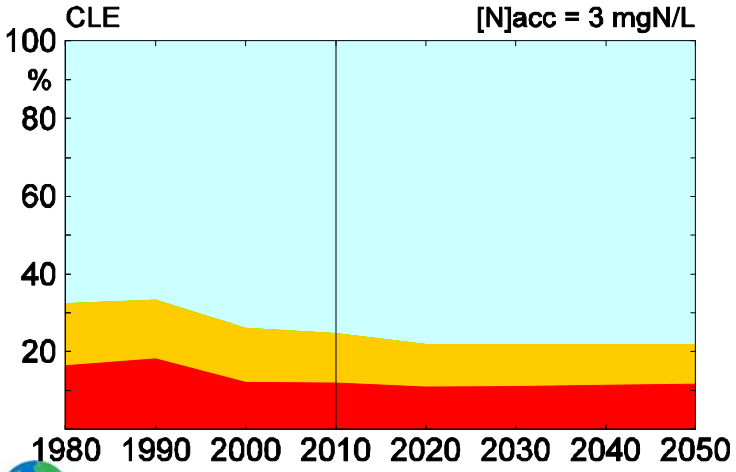
CLE

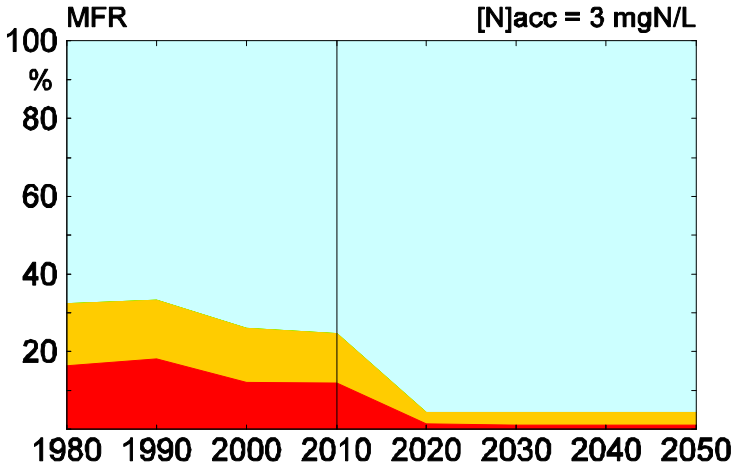


MFR



"Low" $CL_{nut}(N)$



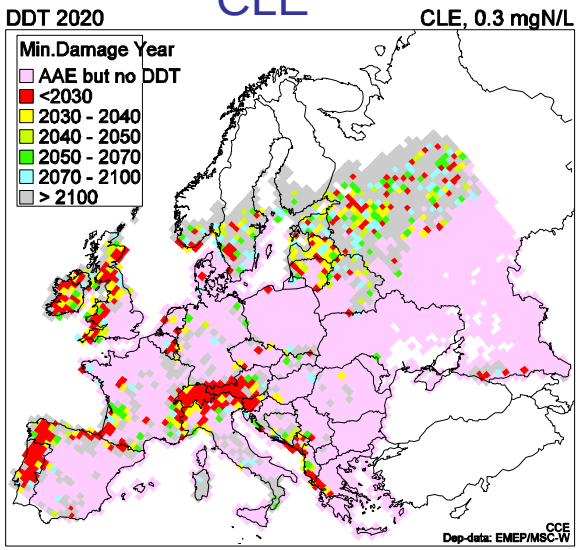


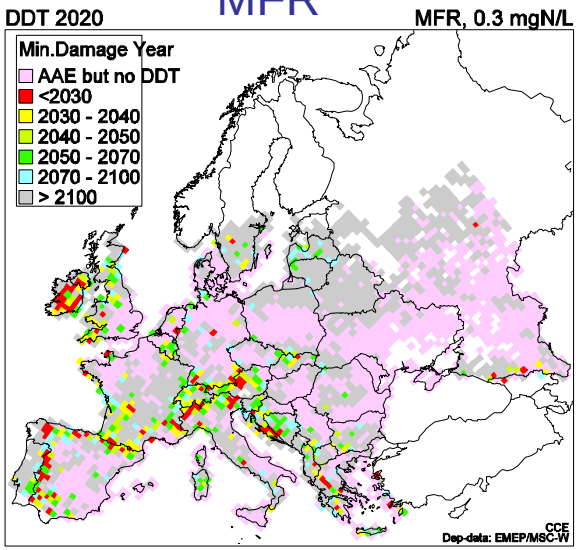
"High" $CL_{nut}(N)$

Damage Delay Times (DDT) under CLE and MFR applied to a low and high $CL_{nut}(N)$; pink means that $CL_{nut}(N)$ is exceeded *and* $[N]_{acc}$ is violated; grey means that DDT > 2100.

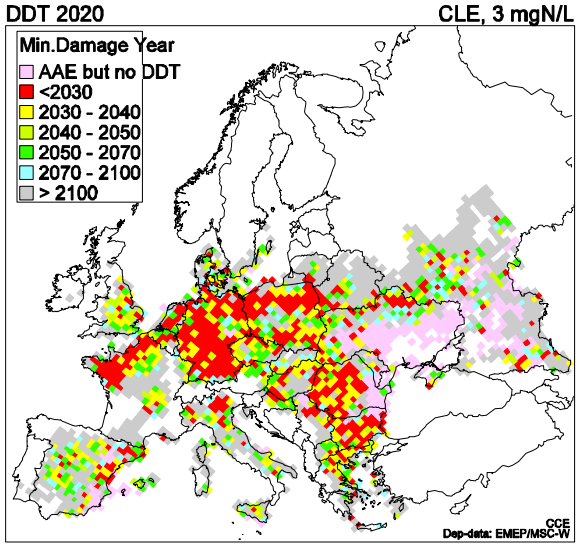
CLE

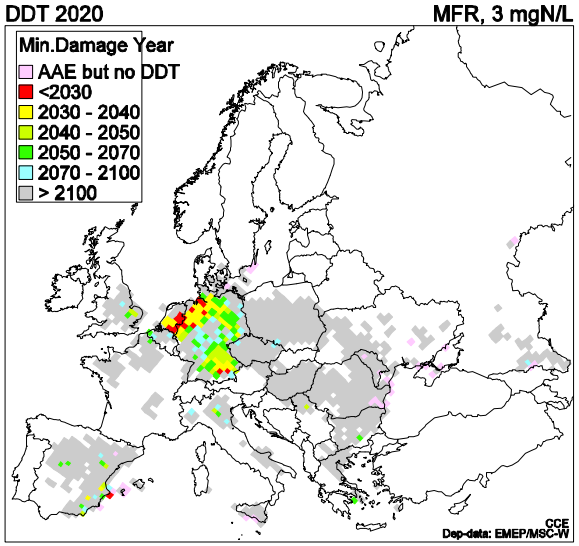
MFR





"Low" $CL_{nut}(N)$





"High" $CL_{nut}(N)$

Conclusions and recommendations

For effect-based Integrated Assessment of N air pollution…

- The use of empirical critical loads and modelled critical loads can improve the robustness of
  - IAM assessments of N-risks (Ensemble Assessment of Impacts),
  - relationships between indicators of effects on soil chemistry and on biology (e.g. species composition, abundance)
- Dynamic modelling provides knowledge on the distribution in Europe of Impact Delay Times (Impact = Recovery or Damage),
- The distribution of Delay Times can be used in the IAM context of optimization, similar to applications with critical loads,
- The limited data requirements of the Very Simple Dynamic (VSD) model has shown to lead to applications by many NFCs. The trade off between data requirements of more complex models, and European wide policy needs should be an issue of ongoing attention in science under the LRTAP Convention.
- European monitoring programmes, such as the ICPs under the LRTAP Convention, are instrumental for the verification of the reliability of model applications.

Recommendations

For effect-based Integrated Assessment of N air pollution including reactive nitrogen…

- Identify common endpoints, common main effects and common side effects (synergies as well as antagonies),
- Explore realistic requirements for critical load approaches on agricultural areas,
- Complete N_r-source, dispersion to impact relationships […from agriculture sources to receptors in managed and natural land…]
- …

Recommended websites

- LRTAP Convention: www.unece.org/env/lrtap/
- ICP Modelling & Mapping: www.icpmapping.org;
- Coordination Centre for Effects: www.mnp.nl/cce;
- European Consortium for Modelling Air Pollution and Climate Strategies (EC4MACS): www.ec4macs.eu/home/index.html