Für Mensch & Umwelt

Umwelt Bundesamt

TFIAM-55, 22.-23. April 2026, Brussels

CCE contribution to the WGE Ex-Post Analyses

Markus Geupel, Christin Loran, Thomas Plha

UNECE

Convention on Long-range Transboundary Air Pollution

Since last meeting in Laxenburg ICP Modelling & Mapping / CCE…

1 … PROVIDED SOME SMALLER UPDATES IN THE EMPIRICAL CRITICAL LOAD DATA

2 … CONTRIBUTED TO THE EX-POST-ANALYSES IN 2025 (REPORT, ANNEXES)

3 … PUBLISHED THE CCE STATUS REPORT IN 2026 (LINKS)

4 … HELD ITS ANNUAL MEETING LAST WEEK IN ROME (LINKS)

Ex-Post analysis of the Working Group on Effects

- Ex post analysis is an analysis where effects are assessed on the basis of deposition and / or concentration fields generated from optimised scenarios from integrated assessment modelling.

- Deposition was provided by MSC-West based on v5 scenarios

- Assessments done throughout 2025 and provided for EB-45

- Contributed to the success that EB-45 in December 2025 decided to use an effects based approach for setting emission reduction commitments including health and biodiversity for negotiation.

Ex-Post analysis of the Working Group on Effects

Joint Activity under Working Group on Effects

- ICP Waters
  - CLE 2040 indicates clear chemical recovery of acidified lakes
  - Additional ambition provides limited extra benefits (due to already reduced Sulphur levels)
- ICP Materials
  - More ambitious scenarios extend maintenance intervals (less soiling and corrosion)
  - MTFR shows the strongest effect, Differences between OPT and OPT_HV are small
- ICP Vegetation
  - Ozone remains a relevant driver of damage (also in 2040)
  - MTFR shows the largest benefits for crop yields and ecosystem health
- ICP Integrated Monitoring
  - Reduced deposition leads to a decline in nitrophilous grasses
  - Moss recovery is gradual, with strongest responses under MTFR

CCE contribution to the Ex-Post analysis

ANALYSIS OF THE EMPIRICAL CRITICAL LOAD EXCEEDANCES: RISKS FOR BIODIVERSITY

- Comparison of the effects of using NFC versus CCE data
- AAE – Average Accumulated Exceedance and AAR – Area at Risk
  - Spatial analysis (maps) and statistics (country-specific, habitat-specific, ecosystem-specific)

CRITICAL LEVELS FOR AMMONIA:

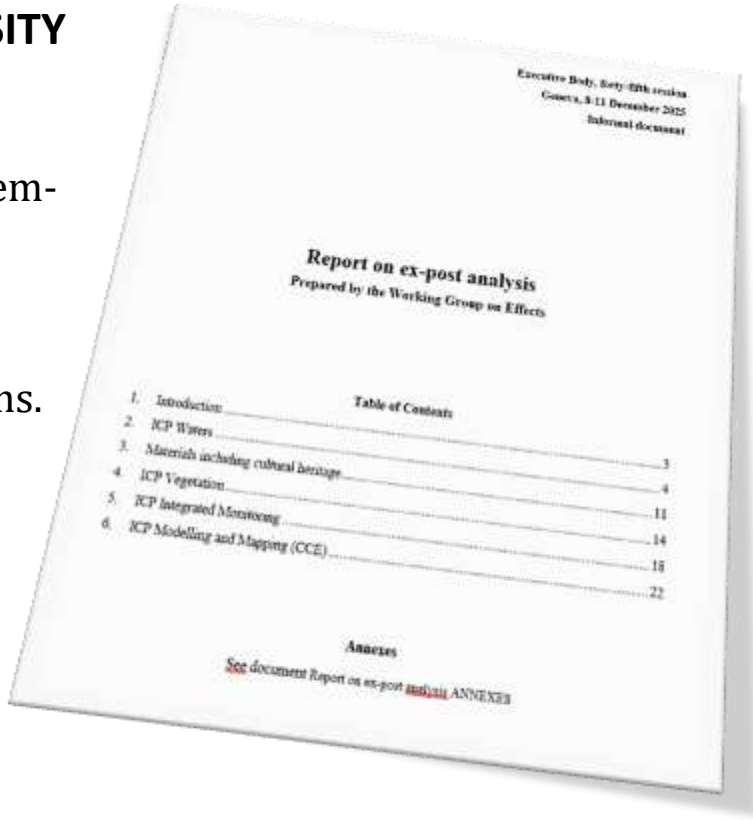
- Several regions in Europe and the EECCA continue to have elevated NH_3 concentrations.
- Exceedances will persist even in 2040.

MODELLED CRITICAL LOAD (FOCUS ON ACIDIFICATION):

- Only a few areas will still be at risk of acidification in 2040.
- Significantly less of a problem compared to N exceedances.

CRITICAL ATMOSPHERIC INPUT (CAI): MARINE ENVIRONMENT OF THE BALTIC SEA

- Only a few sub-regions of the Baltic Sea still at risk from airborne nitrogen.
- Clear improvement under more ambitious scenarios.


Executive Body, Sixty-fifth session
Geneva, 8-11 December 2025
Informal document

Report on ex-post analysis
Prepared by the Working Group on Effects

Table of Contents

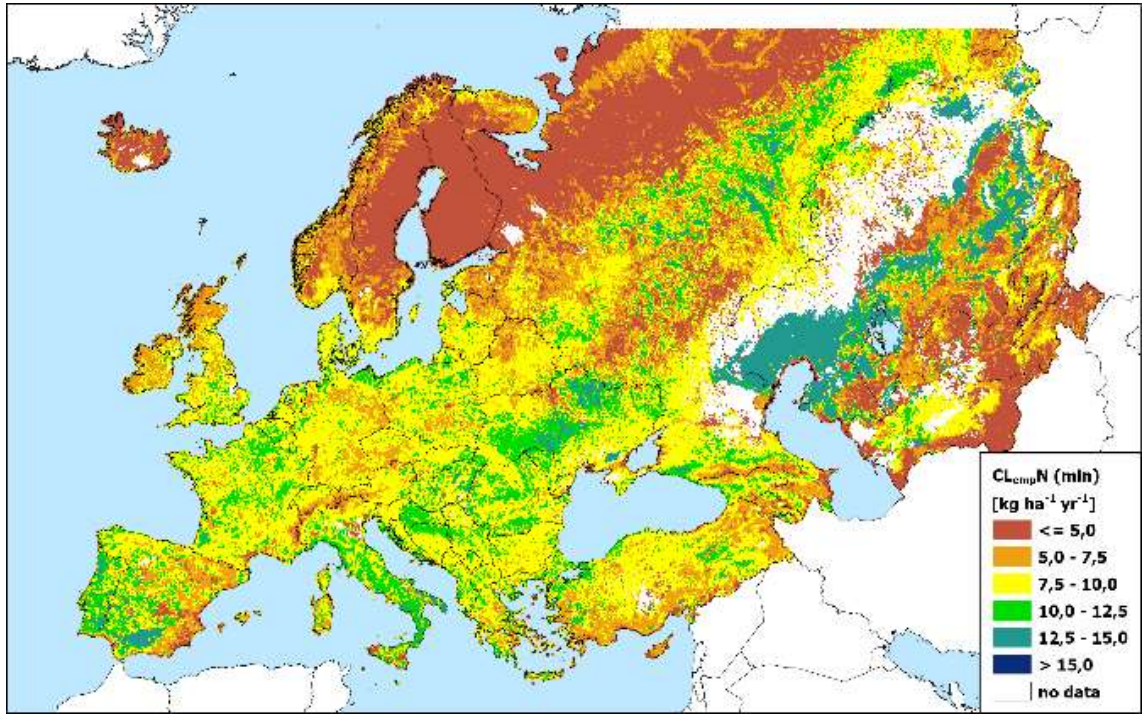
Annexes

See document Report on ex-post analysis ANNEXES

- EB report ex-post analysis Nov 2025 rev_0.pdf; EB report ex-post analysis Nov 2025_Annex.pdf
- **CCE Status Report 2026**

ANALYSIS OF RISKS FOR BIODIVERSITY – different CL data

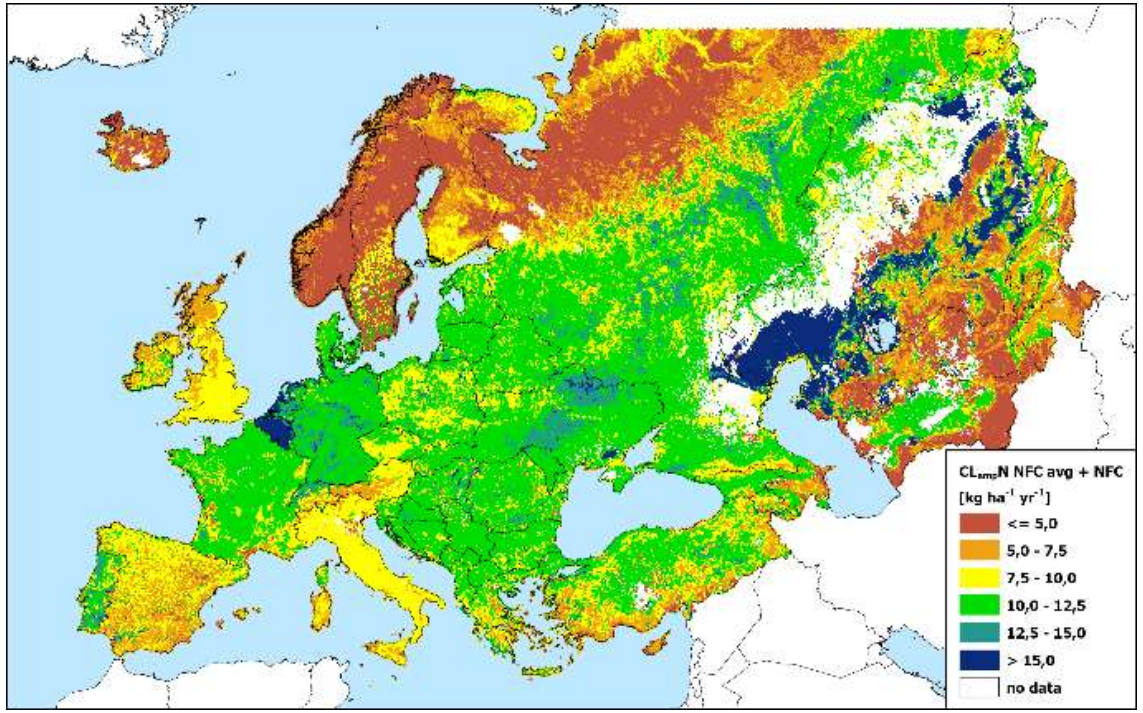
Critical Loads CCE_{min}



for IAM and ex-post

always the minimum of $CL_{emp}N$ ranges

Critical Loads NFC



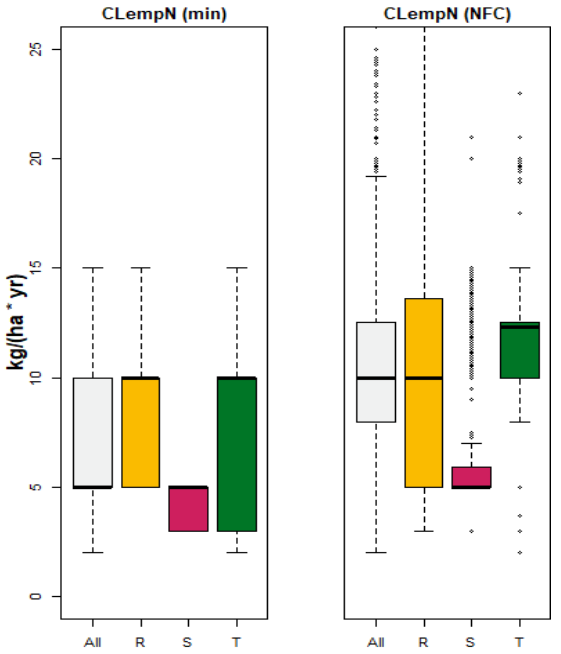
for ex-post only

NFC choice of range, gap-filling average of choices

Ex-Post analysis - ANALYSIS OF RISKS FOR BIODIVERSITY

1 COMPARISON OF DIFFERENT $CL_{EMP}N$ DATA (CCE_{MIN} vs NFC)

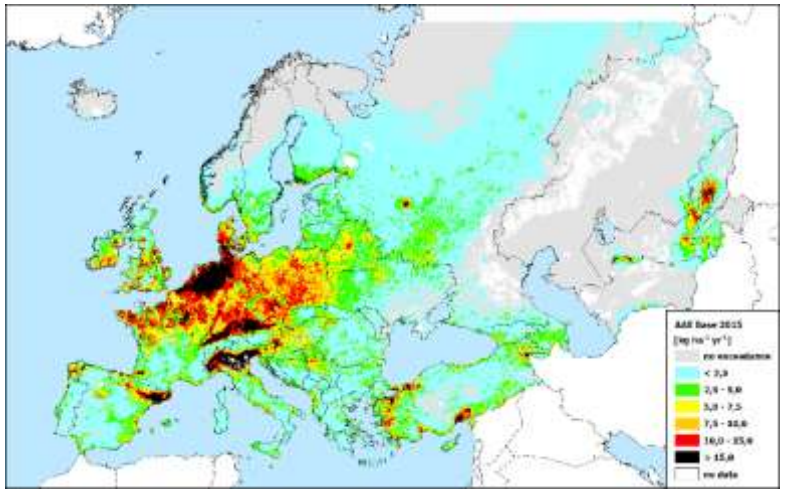
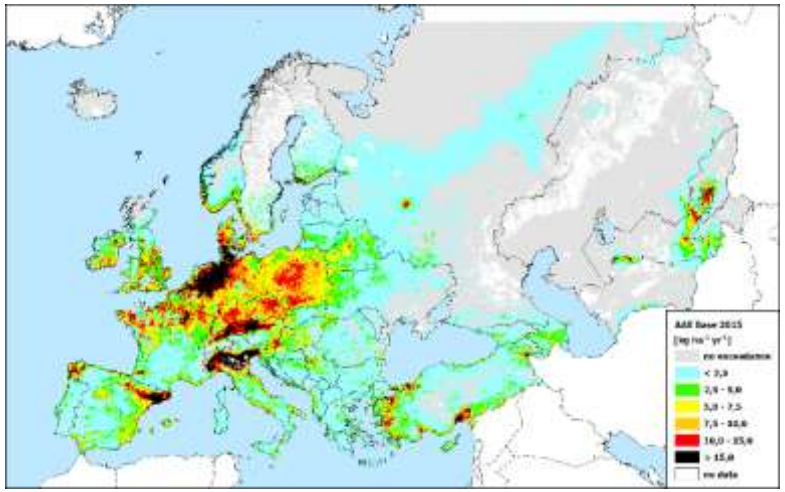
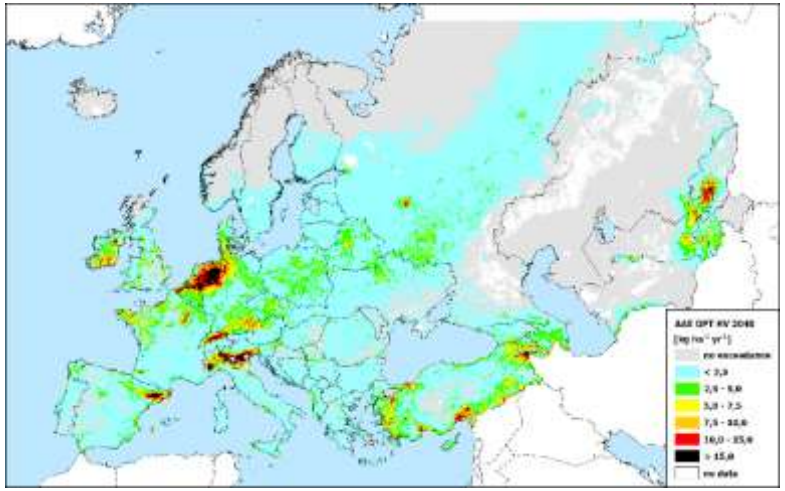
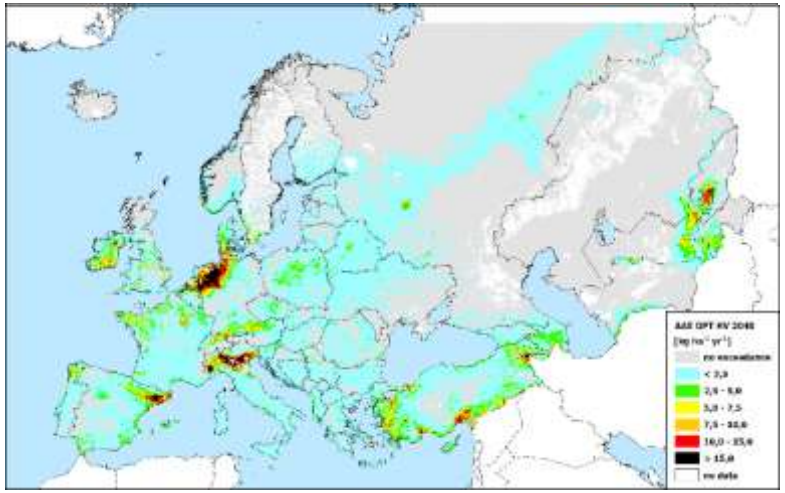
1. Overall CCEmin is more sensitive than NFC
   → more and higher exceedance for CCEmin
2. NFC more accurate and for some countries more sensitive
3. For some NFC more sensitive for single habitats (grassland)
4. The opposite (less sensitivity) is also evident



→ NFC prefer to see their own, national data used in the policy process (most preferably in the IAM)

→ Rom-Meeting 2026 asked CCE to use NFCdata in combination with CCE_{min} for gap-filling in the next update of Ex-Post-Analyses

Ex-Post analysis - ANALYSIS OF RISKS FOR BIODIVERSITY

	Critical Loads CCE_{min}	Critical Loads NFC
2015 base		
Opt-hv		

The scenario which optimizes for the reduction of health and biodiversity effects (OPT_HV_2040) shows additional benefits in reducing nitrogen-related risks in ecosystems compared to the OPT_2040 scenario optimizing on health only.

Ex-Post analysis - ANALYSIS OF RISKS FOR BIODIVERSITY

1 -50% GOAL COMPARED TO BASELINE 2015 ACHIEVABLE (BASED ON CCE_{MIN})?

	CLE 2040		Opt 2040		Opt_hv 2040		MTFR 2040	
	Δ AAE [%]	Δ AAR [%]	Δ AAE [%]	Δ AAR [%]	Δ AAE [%]	Δ AAR [%]	Δ AAE [%]	Δ AAR [%]
EU-27	-69,2	-36,7	-75,6	-43,6	-80,4	-50,1	-87,7	-59,7
Non-EU	-58,3	-42,9	-67,9	-50,6	-69,4	-53,2	-76,5	-62,4
WB countries	-56,9	-38,3	-69,5	-51,3	-80,6	-63,5	-86,8	-73,3
EECCA countries & Turkey	79,5	3,0	19,0	-10,5	-38,1	-22,0	-44,9	-37,3

Under OPT_HV, >50% reduction is achievable in many European countries.
for EECCA region larger risks remain.

AAE: Average Accumulated Exceedance

AAR: Area At Risk

Ex-Post analysis - ANALYSIS OF RISKS FOR BIODIVERSITY

ABSOLUTE EXCEEDANCE ACHIEVABLE (BASED ON CCE_{MIN})? COUNTRIES / REGIONS

	CLE 2040		Opt 2040		Opt_hv 2040		MTFR 2040	
	AAE [kg ha^{-1} a^{-1}]	Δ AAR [%]	AAE [kg ha^{-1} a^{-1}]	Δ AAR [%]	AAE [kg ha^{-1} a^{-1}]	Δ AAR [%]	AAE [kg ha^{-1} a^{-1}]	Δ AAR [%]
EU-27	0,7	38,2	0,6	34,0	0,5	30,1	0,3	24,3
Non-EU	0,4	12,8	0,3	11,1	0,3	10,5	0,2	8,4
WB countries	0,8	32,3	0,5	25,5	0,3	19,1	0,2	14,0
EECCA countries & Turkey	0,3	25,7	0,2	22,3	0,1	19,5	0,1	15,7

Under OPT_HV, **on country level** larger differences: for some countries remaining exceedance rather large

→ In most of the countries low remaining exceedance

AAE: Average Accumulated Exceedance

AAR: Area At Risk

All country tables:

- EB report ex-post analysis Nov 2025 rev_0.pdf; EB report ex-post analysis Nov 2025_Annex.pdf
- **CCE Status Report 2026**

Ex-Post analysis - ANALYSIS OF RISKS FOR BIODIVERSITY

ABSOLUTE EXCEEDANCE ACHIEVABLE (BASED ON CCE_{MIN})? COUNTRIES / REGIONS

Example countries	CLE 2040		Opt 2040		Opt_hv 2040		MTFR 2040	
	AAE [kg ha^{-1} a^{-1}]	Δ AAR [%]	AAE [kg ha^{-1} a^{-1}]	Δ AAR [%]	AAE [kg ha^{-1} a^{-1}]	Δ AAR [%]	AAE [kg ha^{-1} a^{-1}]	Δ AAR [%]
Belgium	6,2	96,9	5,0	90,8	4,7	87,7	3,6	77,8
Germany	4,1	75,0	3,5	68,1	3,4	66,0	2,4	54,4
Netherlands	14,5	99,0	13,7	98,7	13,5	98,6	12,4	98,3
Finnland	0,1	19,1	0,1	16,4	0,1	15,2	0,0	8,8
Norway	0,1	7,4	0,1	6,2	0,1	5,5	0,0	4,0
Kazakhstan	0,1	5,5	0,1	4,5	0,0	3,7	0,0	3,4

Under OPT_HV, **on country level** larger differences: for some countries remaining exceedance rather large

→ In most of the countries low remaining exceedance

AAE: Average Accumulated Exceedance

AAR: Area At Risk

All country tables:

- EB report ex-post analysis Nov 2025 rev_0.pdf; EB report ex-post analysis Nov 2025_Annex.pdf
- **CCE Status Report 2026**

Ex-Post analysis - ANALYSIS OF RISKS FOR BIODIVERSITY

1 -50% GOAL COMPARED TO BASELINE 2015 ACHIEVABLE (BASED ON CCE_{MIN})?

	CLE 2040		Opt 2040		Opt_hv 2040		MTFR 2040	
	AAE [%]	AAR [%]	AAE [%]	AAR [%]	AAE [%]	AAR [%]	AAE [%]	AAR [%]
Inland surface waters(C)	-32,1	-44,7	-43,1	-50,7	-53,8	-52,9	-62,0	-62,1
Marine habitats (M)	101,2	22,4	27,4	4,0	-23,0	-16,3	-33,9	-25,2
Coastal habitats (N)	-44,8	-33,1	-59,7	-52,3	-73,2	-67,6	-79,8	-73,2
Wetlands (Q)	-43,1	-26,8	-57,7	-39,8	-61,5	-43,2	-78,3	-59,3
Grasslands and lands domina-ted by forbs, mosses, or lichens (R)	3,0	-4,1	-20,3	-17,0	-38,4	-29,1	-46,9	-37,2
Heathland, scrub, and tundra (S)	-17,9	-7,3	-29,1	-11,5	-48,4	-19,4	-55,6	-25,3
Forest and other wooded land (T)	-53,7	-20,9	-68,1	-31,1	-81,4	-39,7	-85,9	-53,3

On EUNIS level 1 class grouping the achievement of goals is more difficult

→ however, the total exceedance (AAE kg ha^{-1}) partly very low < 1

AAE: Average Accumulated Exceedance

AAR: Area At Risk

Ex-Post analysis - ANALYSIS OF RISKS FOR BIODIVERSITY

ABSOLUTE EXCEEDANCE ACHIEVABLE (BASED ON CCE_{MIN})? EUNIS 1 / ECOSYSTEMS

EUNIS Level 1 ecosystem classes	CLE 2040		Opt 2040		Opt_hv 2040		MTFR 2040		Area
	AAE [kg ha^{-1} a^{-1}]	AAR [%]	AAE [kg ha^{-1} a^{-1}]	AAR [%]	AAE [kg ha^{-1} a^{-1}]	AAR [%]	AAE [kg ha^{-1} a^{-1}]	AAR [%]	km^2
Inland surface waters(C)	0,2	11,0	0,2	9,8	0,1	9,4	0,1	7,6	2.029
Marine habitats (M)	0,1	1,9	0,1	1,6	0,0	1,3	0,0	1,1	366.206
Coastal habitats (N)	0,3	11,4	0,2	8,1	0,2	5,5	0,1	4,5	5.384
Wetlands (Q)	0,1	5,3	0,1	4,3	0,0	4,1	0,0	2,9	463.866
Grasslands and lands domina-ted by forbs, mosses, or lichens (R)	0,7	26,6	0,6	23,1	0,4	19,7	0,4	17,5	1.433.579
Heathland, scrub, and tundra (S)	1,2	35,0	1,1	33,5	0,8	30,5	0,7	28,2	448.142
Forest and other wooded land (T)	0,3	32,6	0,2	28,4	0,1	24,9	0,1	19,2	5.083.372

For specific ecosystems the picture is diverse

→ For some, being close to CL (0,0 AAE kg ha^{-1}) is possible

→ For some, larger remaining exceedance on a rather large share of the total area

AAE: Average Accumulated Exceedance

AAR: Area At Risk

Ex-Post analysis - ANALYSIS OF RISKS FOR BIODIVERSITY

ABSOLUTE EXCEEDANCE ACHIEVABLE (BASED ON CCE_{MIN})? EUNIS 1 / ECOSYSTEMS

example ecosystems of EUNIS class R "Grasslands"	CLE 2040		Opt 2040		Opt_hv 2040		MTFR 2040		Area
	AAE [kg ha^{-1} a^{-1}]	AAR [%]	AAE [kg ha^{-1} a^{-1}]	AAR [%]	AAE [kg ha^{-1} a^{-1}]	AAR [%]	AAE [kg ha^{-1} a^{-1}]	AAR [%]	km^2
Low and medium altitude hay meadow (R22)	1,2	28,5	0,9	23,6	0,8	18,3	0,6	14,4	286.710
Mountain hay meadow (R23)	0,7	18,0	0,6	16,5	0,3	11,2	0,3	10,9	4.010
Moist or wet mesotrophic to eutrophic hay meadow (R35)	0,0	0,7	0,0	0,5	0,0	0,3	0,0	0,1	255.254
Temperate and boreal moist or wet oligotrophic grassland (R37)	1,2	29,9	1,0	24,4	0,9	23,0	0,5	17,6	1.997
Boreal and arctic acidophilous alpine grassland (R42)	0,0	0,2	0,0	0,2	0,0	0,1	0,0	0,1	142.690
Temperate acidophilous alpine grassland (R43)	2,5	66,9	2,1	61,0	1,6	55,9	1,5	51,5	122.437
Arctic-alpine calcareous grassland (R44)	2,9	84,2	2,3	78,3	1,8	73,4	1,5	56,7	43.008

For specific ecosystems the picture is diverse

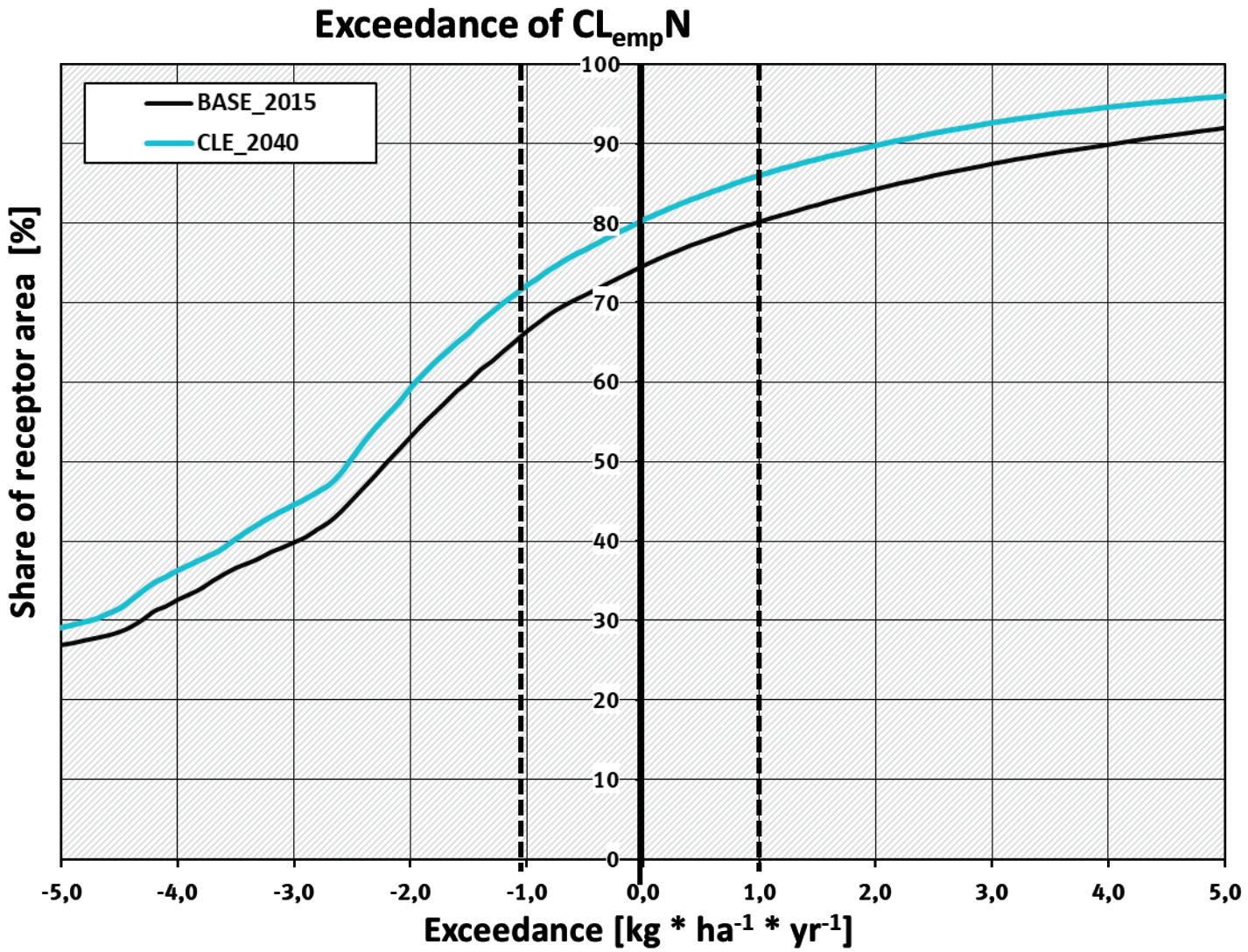
→ For some, being close to CL (0,0 AAE kg ha^{-1}) is possible

→ For some, larger remaining exceedance on a rather large share of the total area

AAE: Average Accumulated Exceedance

AAR: Area At Risk

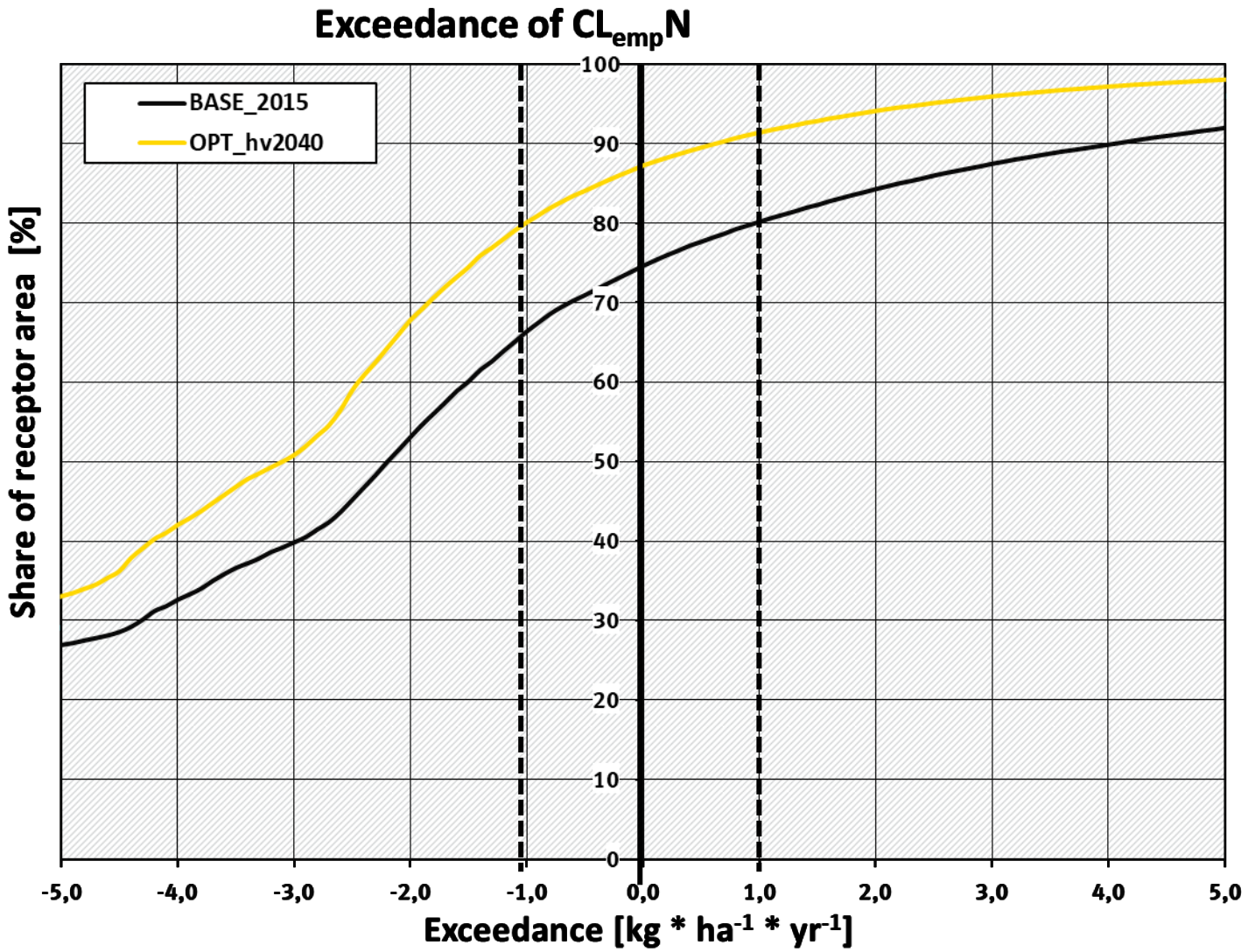
Very first sensitivity analysis



1 kg exceedance rather small, taking into account uncertainties in

- Receptor mapping
- $Cl_{emp}N$ setting
- Emission reporting
- Deposition modelling

Very first sensitivity analysis



1 kg exceedance rather small, taking into account uncertainties in

- Receptor mapping
- $Cl_{emp}N$ setting
- Emission reporting
- Deposition modelling

Ex-Post analysis - ANALYSIS OF RISKS FOR BIODIVERSITY

COUNTRY DATA (CCE_{MIN})

AAR -50 % compared to 2015:

22 countries/regions (OPT 2040)

26 countries/regions (OPT_hv 2040)

AAE <1 kg ha^{-1} a^{-1} :

28 countries/regions (OPT 2040)

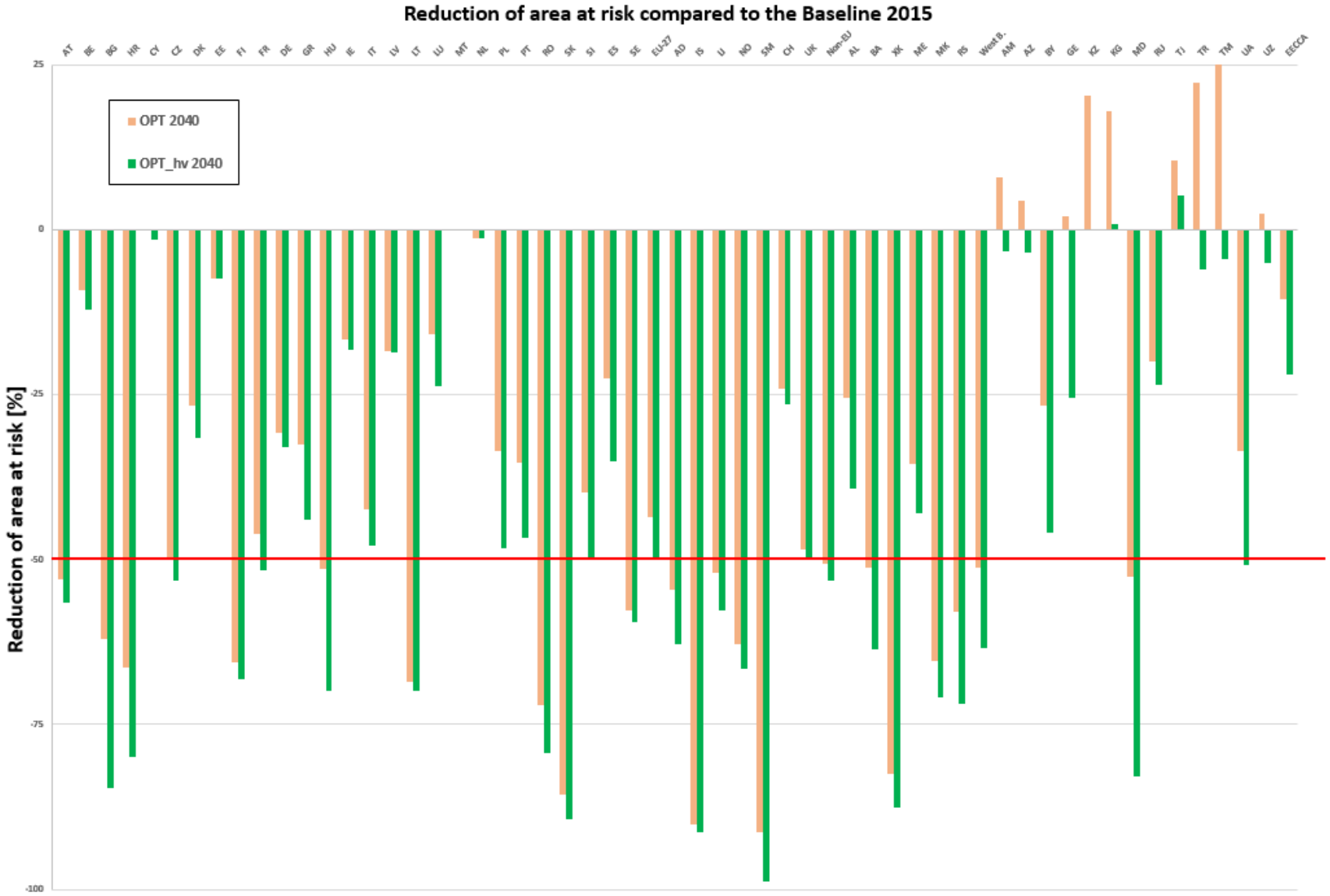
33 countries/regions (OPT_hv 2040)

Largest remaining AAE (kg ha^{-1} a^{-1})

NL: 13,5

BE: 4,7

DE: 3,4



Ex-Post analysis - ANALYSIS OF RISKS FOR BIODIVERSITY

ECOSYSTEM DATA (CCE_{MIN})

(R=GRASSLANDS)

AAR -50 % compared to 2015:

5/14 R ecosystems (OPT 2040)

6/14 R ecosystems (OPT_hv 2040)

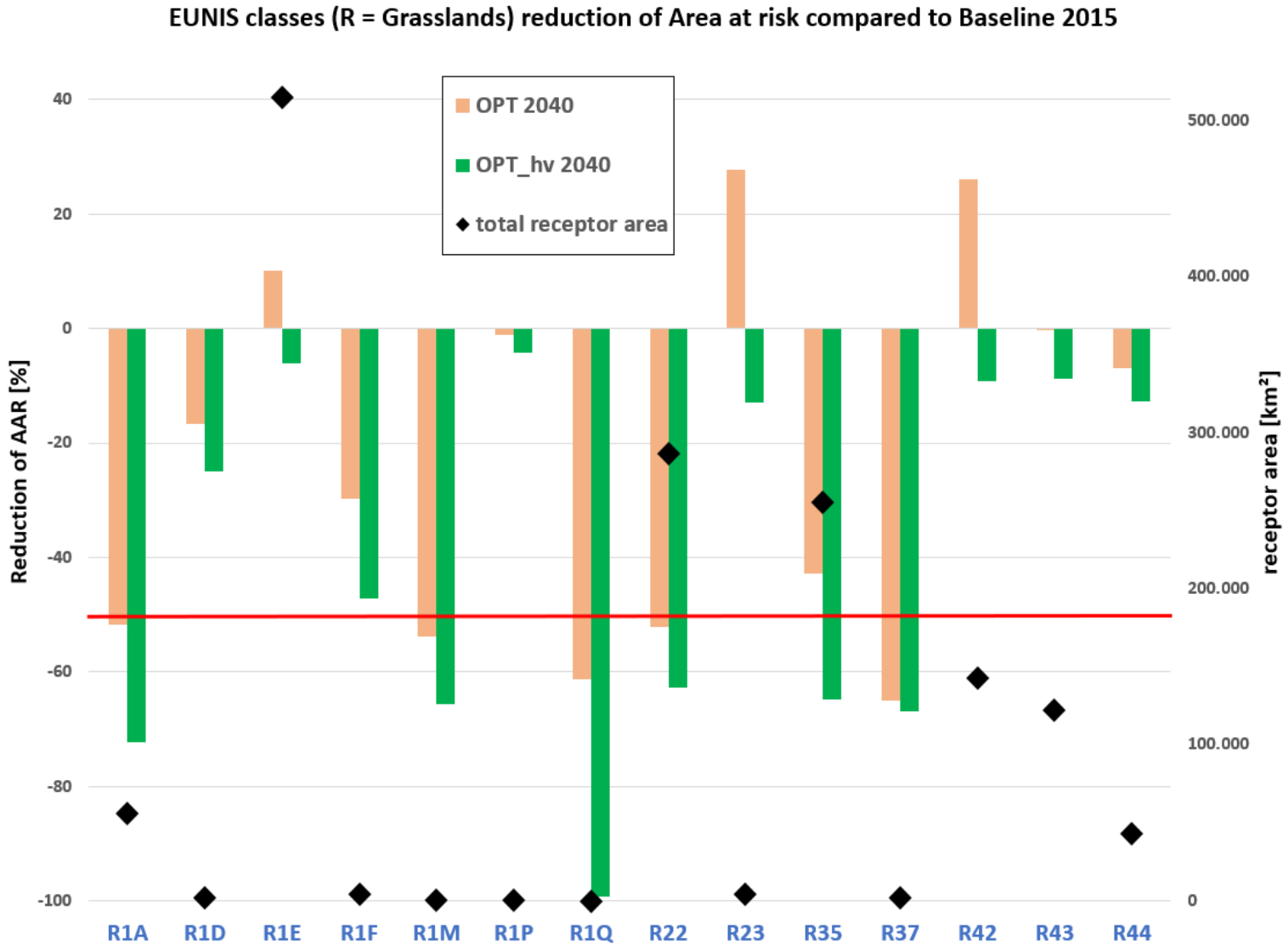
AAE <1 kg ha^{-1} a^{-1} :

9/14 ecosystems (OPT 2040)

9/14 ecosystems (OPT_hv 2040)

Largest remaining AAE (kg ha^{-1} a^{-1})

R1D: 1,9



Summary

- it is welcomed to see effects are being taken into account in the derivation of the ERC (EB-45) and that this could be supported by WGE ex-post analysis
- We are happy to see biodiversity effects included
- It could be pointed out clearly, that involving biodiversity targets in the joint optimization leads to larger compliance with -50% targets
- Diverse picture of exceedance CLempN and achievement of 50%-target on regional, country and ecosystem(class) level
- Absolute exceedance in the majority of ecosystems and countries rather small
- AAE=0 kg ha^{-1} a^{-1} is to be handled with care for absolute target evaluation
- First sensitivity analysis with 1 kg ha^{-1} a^{-1}
- Will be further analyzed with the next updated scenarios for ex-post assessment

Questions? Comments? Remarks?

Website:

www.umweltbundesamt.de/en/cce

Contact:

cce@uba.de