Calculation of LCA characterization factors for terrestrial eutrophication at regional scale

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OUTLINE OF THE PRESENTATION

1) Introduction

2) Terrestrial Eutrophication

3) Development of regional characterization factors

4) Conclusions

Introduction

Quality of the dada

- Absence of reliable or relevant data or in the adequate unit

Diversity of methodologies

- Different types of impact categories
- Different types of models, specially for toxicity
- Lack of trackability

Scarce uncertainty analysis

- Uncertainty in the parameters, scenarios and models

Need of higher development of the characterization factors

- Spatial, temporal and causality chain definition

Spatial definition

Site-independent impact categories

- Produced by contaminants [illegible] allo[illegible]o distribute globally and therefore, their effect is independent of the [illegible] example: [illegible] o [illegible]

Global

Characterization factors

Regional

Site-dependent impact categories

- Produced by emissions of substance[illegible] re[illegible] which are transported hundred or m[illegible]rs. Aquatic eutrophication or acidification

Local

Terrestrial Eutrophication

American Center for Life Cycle Assessment IX Conference 'toward the global life cycle economy"
Boston, 28th September -2ndOctober 2009

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TERRESTRIAL EUTROPHICATION

Effects

Deposition of aerial nitrogen compounds (NO_x and NH_x)

Growth and competitiveness of vegetation in natural ecosystems controlled by the limited availability of N

Decrease in biodiversity due to competitive substitution

Sensitivity of vegetation to disease, drought, frost and herbivores increases

Terrestrial eutrophication is a main threat in Galicia (Cuesta *et al.*, 2008; Rodríguez y Macías 2006):

- Deposition >15 kg N/ha in 69% of the Galician forest
- Critical loads exceeded in 40% of the forest
- Atlantic heathlands (protected natural areas) and macrofauna associated are very vulnerable

Terrestrial eutrophication in LCA

EMEP, RAINS, EcoSense
Models relate emissions and critical loads

Spatial differenciation: Country in Europe

Characterization factors at lower scale

Regional factors for terrestrial eutrophication

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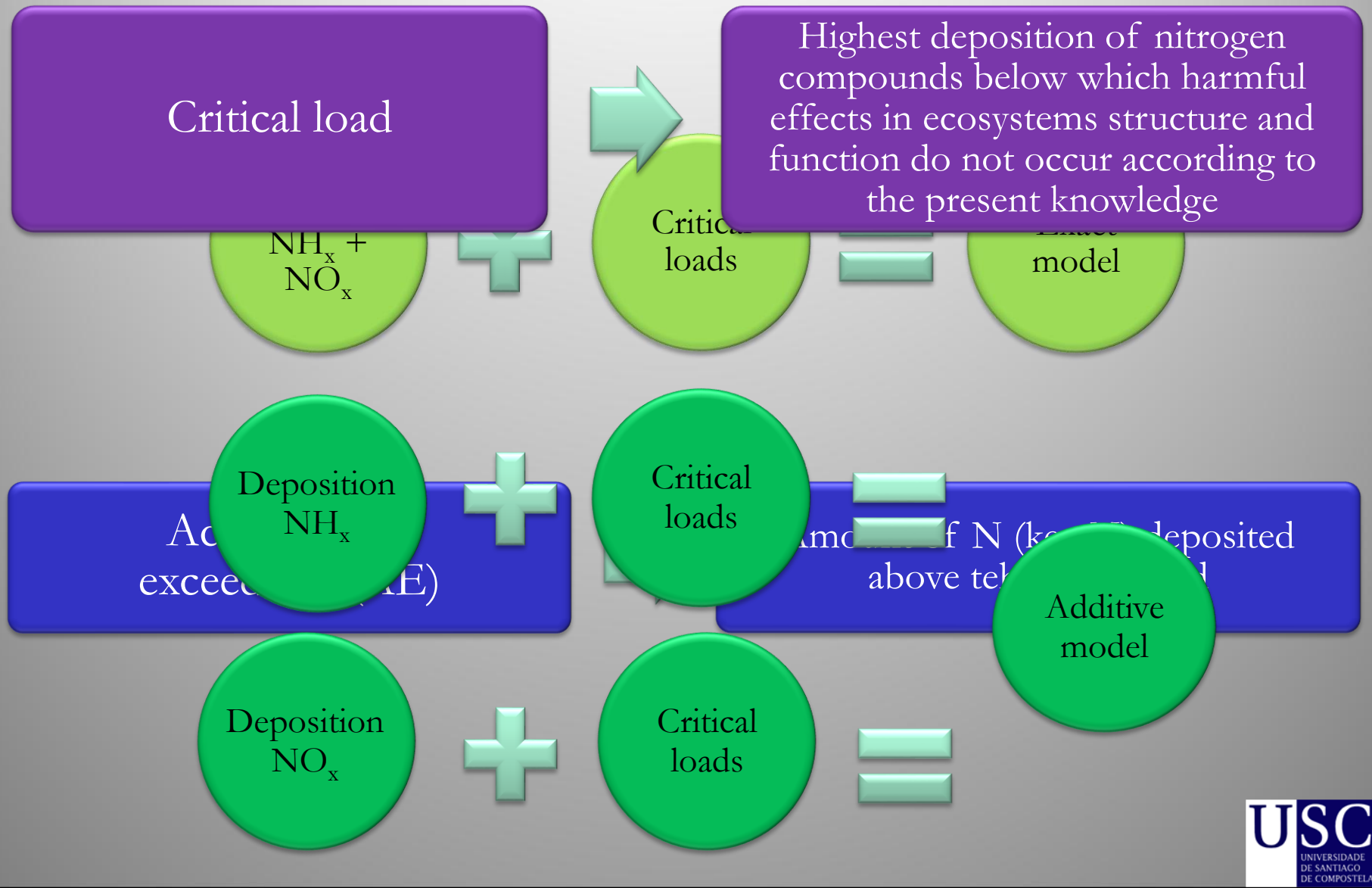

Critical load
Highest deposition of nitrogen compounds below which harmful effects in ecosystems structure and function do not occur according to the present knowledge
NH_x + NO_x
Critical loads
model
Deposition NH_x
Critical loads
Additive model
Deposition NO_x
Critical loads

Methodology from Seppälä *et al.* (2006)

Calculation of regional characterization factors (CAE) for contaminants B (NO_x or NH_x):

$$CAE_B = \frac{\Delta AE^{X\_B}}{\Delta E_{X\_B}} = \frac{AE - AE^{X\_B}}{E_B - E_{X\_B}}$$

AE= Total accumulated exceedance per year (keq/yr)

AE^{X_B}= Total accumulated exceedance after an certain amount of annual variation of the emissions of pollutant B (keq/año)

E_B= Annual emissions of pollutant B (t/yr)

E_{X_B}= Emissions of B after the variation X (t/yr)

Characterization error

$$Err_{ab} = AE - AE^{X\_NO_x, X\_NH_x} - CAE_{NO_x} \cdot \Delta E_{NO_x} - CAE_{NH_x} \cdot \Delta E_{NH_x}$$

AE = Total accumulated exceedance per year [keq/yr]

$AE^{X\_NOx,\ X\_NHx}$ = Total accumulated exceedance in the region of interest after X emission variation of NO_x and NH_x (keq/yr)

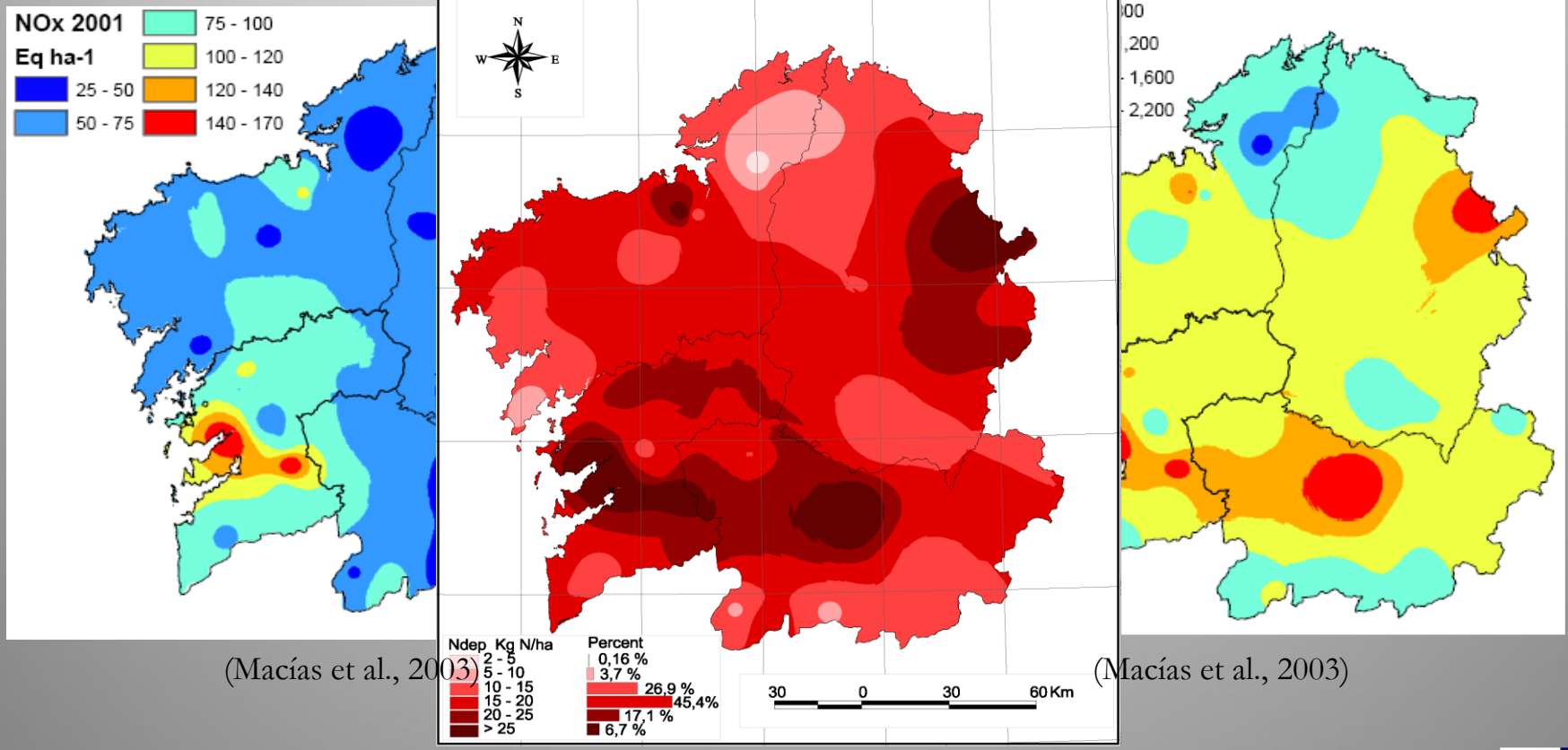
$CEA_{NOx,NHx}$ = Characterization factors for NO_x y NH_x (keq/t)

$\Delta E_{NOx,NHx}$ = Variation X of emissions (t)

Results of the exact model

Results of the additive model

Deposition of nitrogen compounds



(Macías et al., 2003)

(Macías et al., 2003)

(Rodríguez and Macías, 2006)

Calculation of critical loads (Posch et al. 1995)

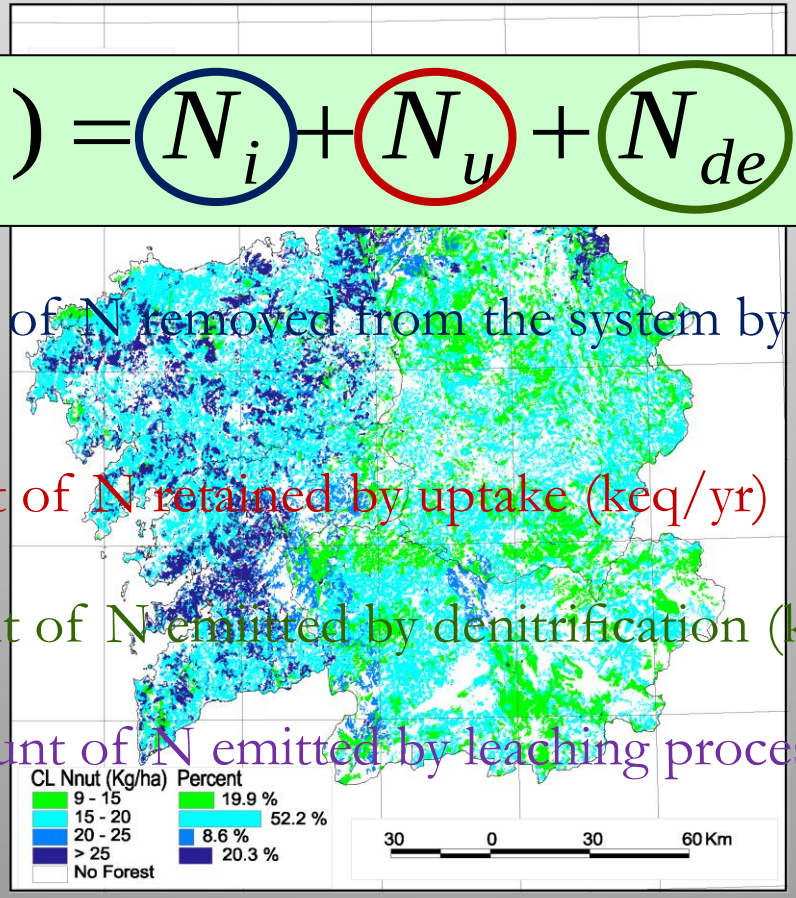
$$CL(N_{nut}) = N_i + N_u + N_{de} + N_{le(crit)}$$

N_i = Amount of N removed from the system by immobilization (keq/yr)

N_u = Amount of N retained by uptake (keq/yr)

N_{de} = Amount of N emitted by denitrification (keq/yr)

$N_{le(crit)}$ = Amount of N emitted by leaching processes (keq/yr)



(Rodríguez and Macías, 2006)

REGIONAL FACTORS FOR TERRESTRIAL EUTROPHICATION

Calculation of characterization factors

NH_x (as NH_3)		NO_x (as NO_2)		Characterization error (%)
ΔE_{X_NHx} (t)	CAE_{NHx} (keq/t)	ΔE_{X_NOx} (t)	CAE_{NOx} (keq/t)	
1	1,96	1	0,074	-0,05
100	1,96	100	0,074	-0,09
175	1,95	318	0,074	-0,10
351	1,94	636	0,074	-0,17
351	1,93	954	0,074	-0,25
701	1,92	1.273	0,074	-0,33
1402	1,87	2.545	0,074	-0,69
2.103	1,82	3.818	0,073	-1,05
2.804	1,78	5.090	0,073	-1,38
3.505	1,74	6.363	0,073	-1,75
4.206	1,69	7.636	0,073	-2,14
4.907	1,65	8.908	0,073	-2,54
5.608	1,61	10.181	0,073	-2,88
6.309	1,57	11.453	0,072	-3,23
7.010	1,53	12.726	0,072	-3,57
14.020	1,17	25.452	0,071	-7,63
21.031	0,91	38.178	0,069	-11,92
28.041	0,72	50.904	0,068	-17,13
35.051	0,57	63.630	0,066	-21,00

Comparison of characterization factors			
	Seppälä et al. (2006)		Gallego (2008)
	Characterization NO_x (keq/t)	Characterization NH_x (keq/t)	Characterization error (%)
Galicia	0,074	1,96	-0,09
Spain	0,877	3,43	-0,01
Emissions	EMEP/CORINAIR Guide		EMEP/CORINAIR Guide
Area of interest	Europe		Galicia
Year	2002		2001

REGIONAL FACTORS FOR TERRESTRIAL EUTROPHICATION

Uncertainties and possible improvements

Critical loads

- Increase our knowledge of the spatial distribution estimates of biomass productivity of forest stands and their uptake rates and spatial distribution of Galician forest
- Obtain specific values of N denitrification and N critical leaching for Galicia

Deposition of contaminants

- Increase the monitoring stations, trying to measure the deposition in areas that are currently not well covered

Emissions

- NH_x, emissions factors more adapted to the Galician conditions for livestock emissions
- NO_x, specific data for Galicia for agricultural, fishery and forest vehicles and maritime transport

Conclusions

Conclusions

The Galician characterization values obtained are different that those obtained for a higher scale (Spain), but a more detailed comparison of both studies is required in order to calculate the exact value of the uncertainties associated with each characterization factor.

Accumulated exceedance is a good category indicator because it allows to obtain stable characterization factors and appropriate characterization errors **with low variations in emissions** (<100 t) which is typical for LCA applications.

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