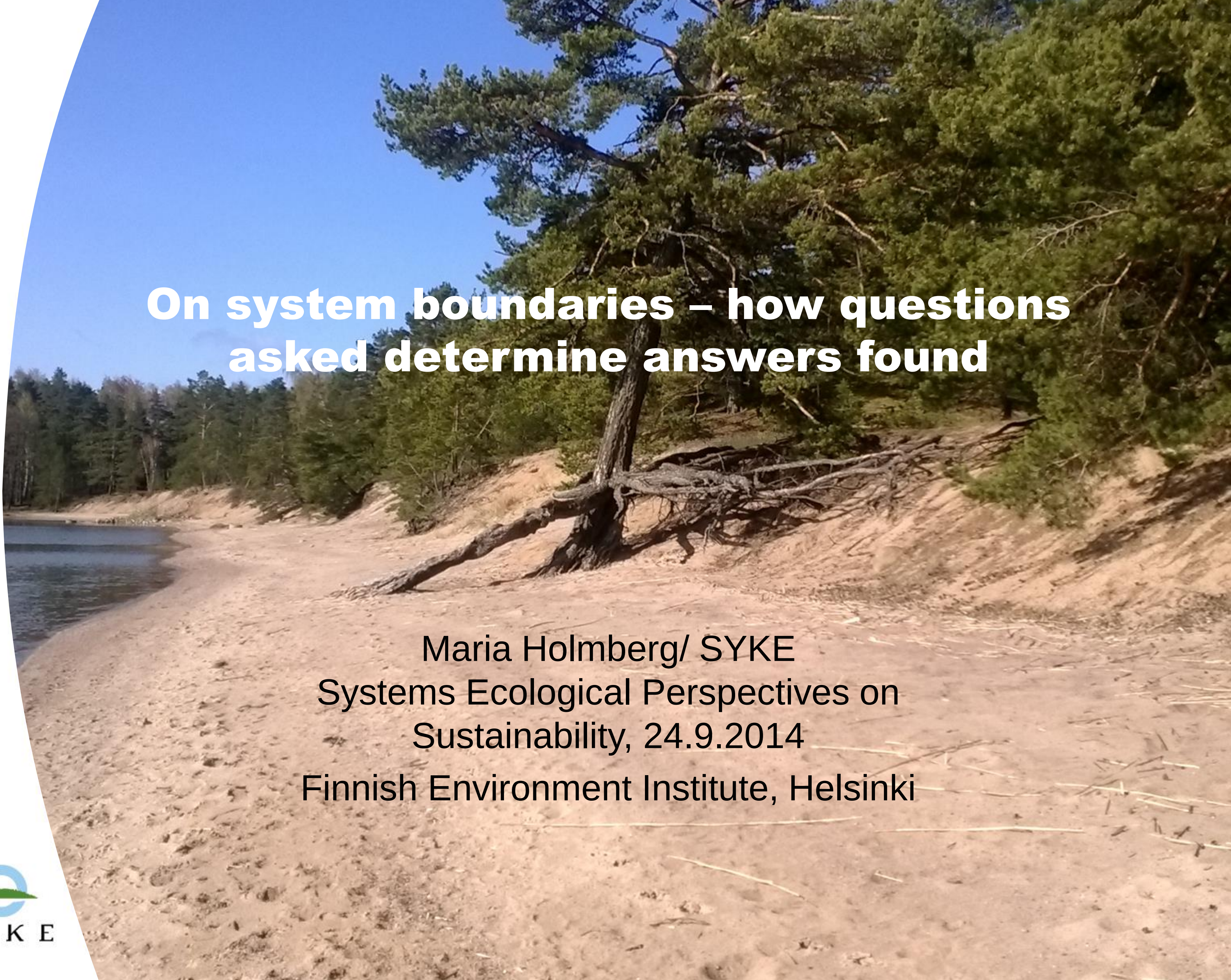

On system boundaries – how questions asked determine answers found

Maria Holmberg/ SYKE

Systems Ecological Perspectives on Sustainability, 24.9.2014

Finnish Environment Institute, Helsinki

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On system boundaries – how questions asked determine answers found

Outline

- Context
    - Sustainability
- Question
    - How can system analysis help find sustainable future?
- Examples from air pollution abatement
    - Acidification – Success story
    - Eutrophication – Ongoing challenge
- Summary

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Key questions to focus on

- Defining key features of the system
  - Variables, indicators
  - *Who defines the indicators?Society, scientists, stakeholders?*
- Selecting reference conditions
  - Critical thresholds
  - *Who defines the reference state? Society, scientists, stakeholders?*
- Communicating methods, aims and results
  - Across disciplines: natural and social sciences
  - Within society: laymen, media, experts, scientists, decision makers
  - How to improve communication?

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Sustainability, sustainable development

Magee et al. 2013

- Sustainability, sustainable development
  - Limits of growth, Club of Rome 1972
  - Brundtland report
  - UN Agenda 21
- Sustainability assessment
  - Assessing for sustainability (Pope et al. 2004)

Sustainability indicators

Top-down or Bottom-up approach

- Top-down
  - Formal methods, standardized indicator sets
  - Conducted regularly (annually)
  - Auditing assurance
  - May or may not lead to policy outcomes
- Bottom-up
  - Qualitative
  - Locally grown measures
  - NGOs
  - Subnational or municipal authorities
  - Community groups

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Sustainability indicators

- Wilson et al 2007 review most prevalent indexes:
  - Ecological footprint
  - Surplus bio-capacity index
  - Environmental sustainability index
  - Well-being index
  - Gross domestic product index
- Parris and Kates 2003 analyse 12 sustainability indicator initiatives
  - Extract common features in their respective definitions of sustainability
- Ness et al 2007 develop a topology of various assessment tools
- Singh et al 2009 review of 70 indicators, tools and methodologies

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United Nations Global Compact

- The UN Global Compact is a strategic policy initiative for businesses that are committed to aligning their operations and strategies with ten universally accepted principles in the areas of human rights, labour, environment and anti-corruption. By doing so, business, as a primary driver of globalization, can help ensure that markets, commerce, technology and finance advance in ways that benefit economies and societies everywhere.
- 145 countries, 8 000 businesses, 53 Finnish companies
- https://www.unglobalcompact.org

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UN Global Compact Cities Programme

https://www.unglobalcompact.org/ParticipantsAndStakeholders/cities.html/

Translating sustainability principles into urban governance

34 countries participating	Number of cities
Africa	3
Asia	13
Australia	1
Europe	29
Middle East	4
North America	4
South America	37

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UN Global Compact Cities Programme

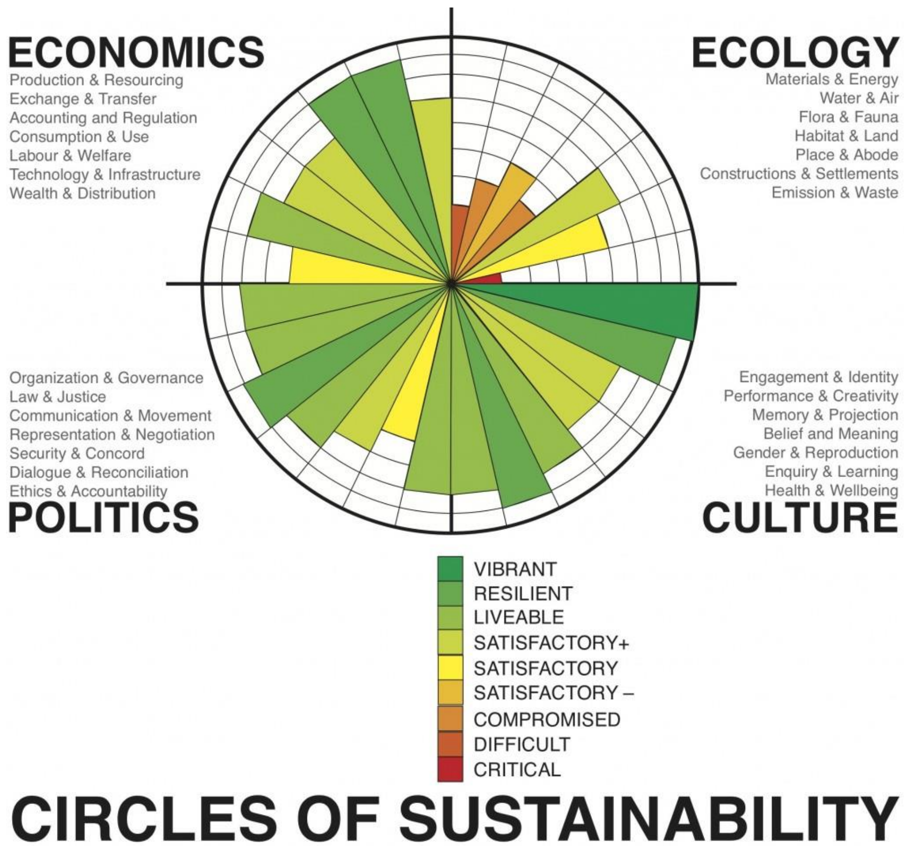
https://www.unglobalcompact.org/ParticipantsAndStakeholders/cities.html/

Urban Profile Process

- Interpretative description of the sustainability of an urban region and its immediate hinterland
- ‘Sustainability’ understood in relation to local, national and global processes:
  - Ecological,
  - Economic,
  - Politic, and
  - Cultural processes
- Assessment group: three to ten people
  - Expert knowledge: internal, external
  - Extensive local knowledge

UN Global Compact Cities Programme

https://www.unglobalcompact.org/ParticipantsAndStakeholders/cities.html/



Four domains: Ecology, Economics, Politics, Culture

Seven issues per domain , seven questions per issue: 196 questions

Nine point scale of sustainability, from critical to vibrant

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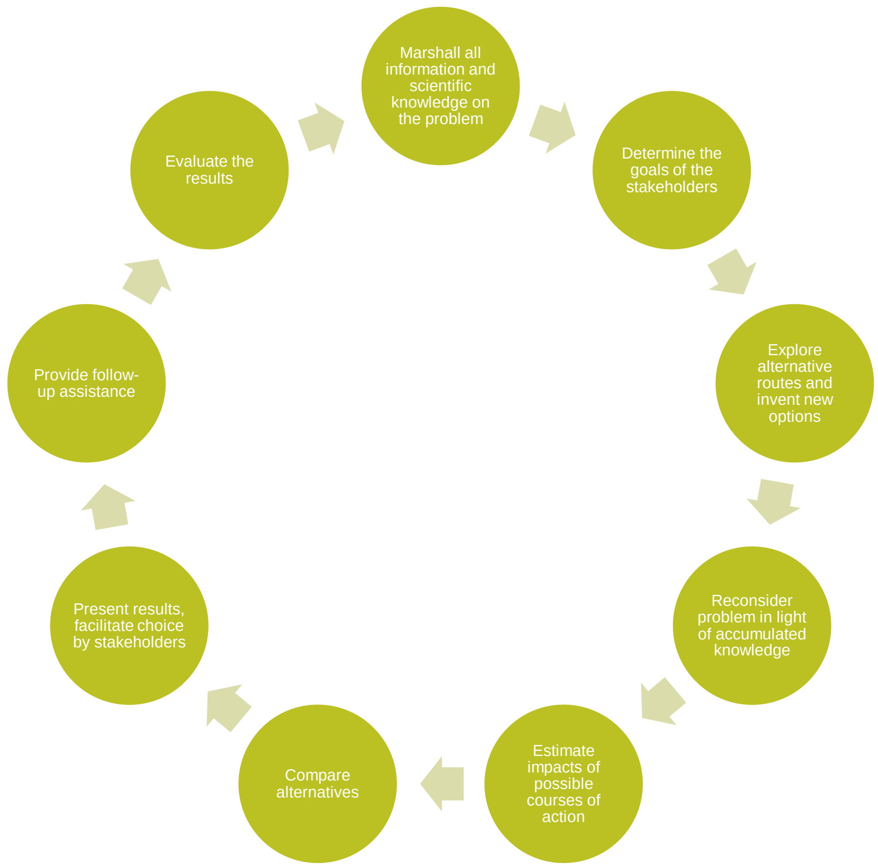
What is systems analysis?

Leen Hordijk, IIASA director 2002 - 2008, IIASA Options Magazine, Winter 2007

- A problem-solving process in which many people take part:
  - Scientists of relevant disciplines
  - Stakeholders
  - Decision makers
- Factors included
  - Knowledge and methods of science and technology
  - Concept of social goals and equities
  - Elements of judgment and taste
  - Consideration of larger context and uncertainties
- Both quantitative and qualitative side

Iterative process of systems analysis



Following Leen Hordijk's 9 steps of systems analysis, IIASA Options Magazine, Winter 2007

System boundaries

State variables and indicators

- State variables are the key units of the process studied:
  - Acidification
    - Soil pH, Al, base cations
  - Eutrophication:
    - Soil N, soil pH
- Indicators derived from the state variables and processes
  - Acidification
    - Al/BC in soil solution
    - Soil BS
  - Eutrophication
    - Species cover, habitat suitability, Bray-Curtis index

System boundaries

Processes included, process rates

- Processes describing key features of system studied
  - Acidification
    - Cation exchange, weathering, gibbsite equilibrium, leaching of organic anions, complexation with soil organic matter
  - Eutrophication
    - N fixation, mineralisation, nitrification, denitrification, N uptake by vegetation, litterfall

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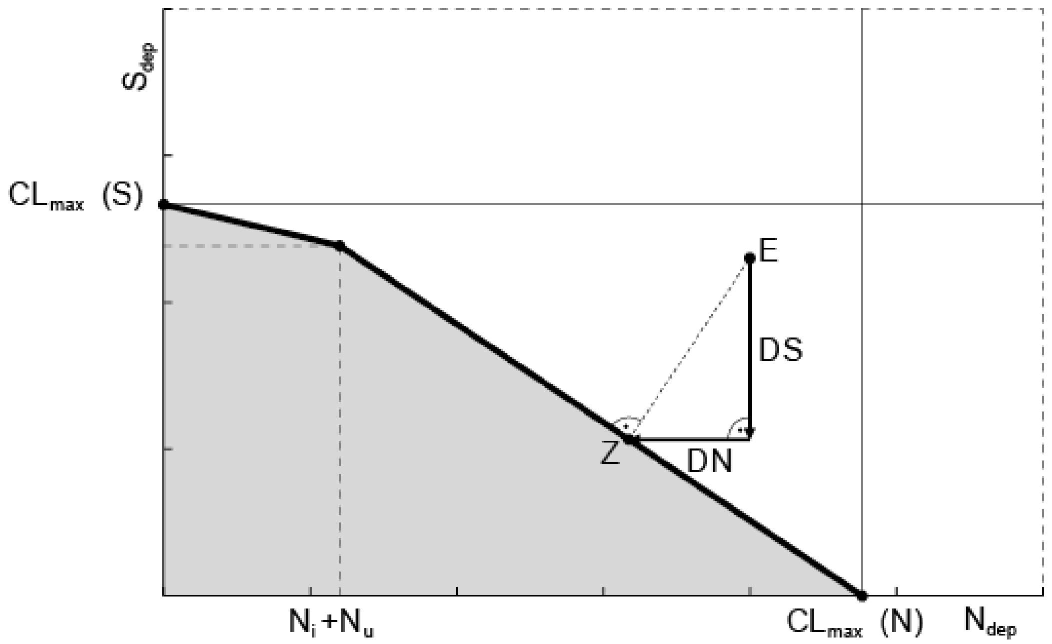
Success story: Acidification load decline

UNECE/ CLRTAP
Convention on Long Range Transboundary Air Pollution

- Signed in 1979, entered into force in 1983
- First regional environmental convention, 51 parties
- Instrumental in reducing key harmful pollutants in Europe and North America
- Eight protocols, targeting pollutants:
  - sulphur, nitrogen oxide, persistant organic pollutants, volatile organic compounds, toxic heavy metals
- Integrated assessment modelling
- Effects based approach
- Critical loads

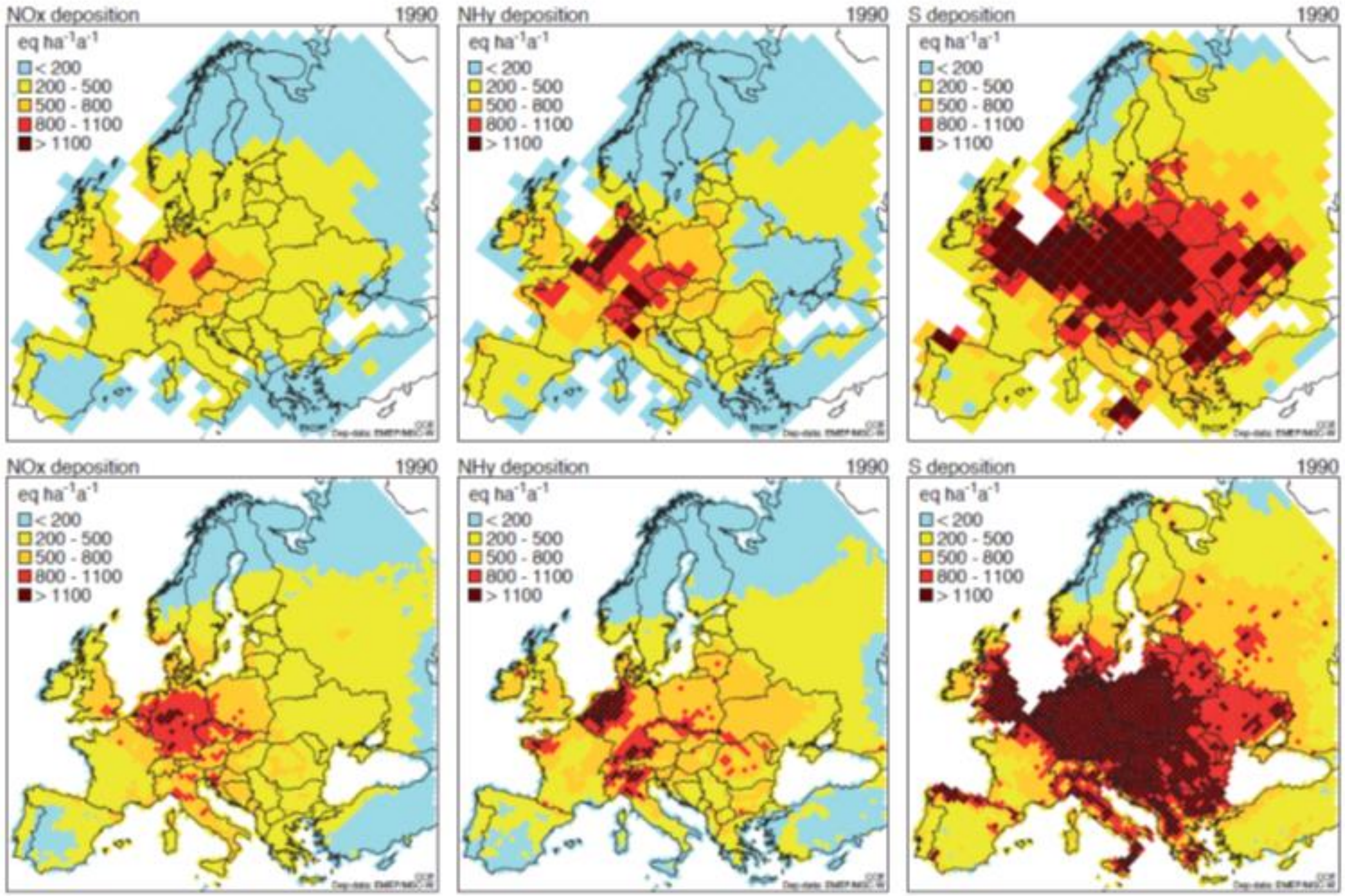
Effects-based approach of air pollution abatement



Critical load function of the ecosystem: the combination of N and S deposition not causing harmful effects

http://wge-cce.org/Methods_Data/Critical_Loads

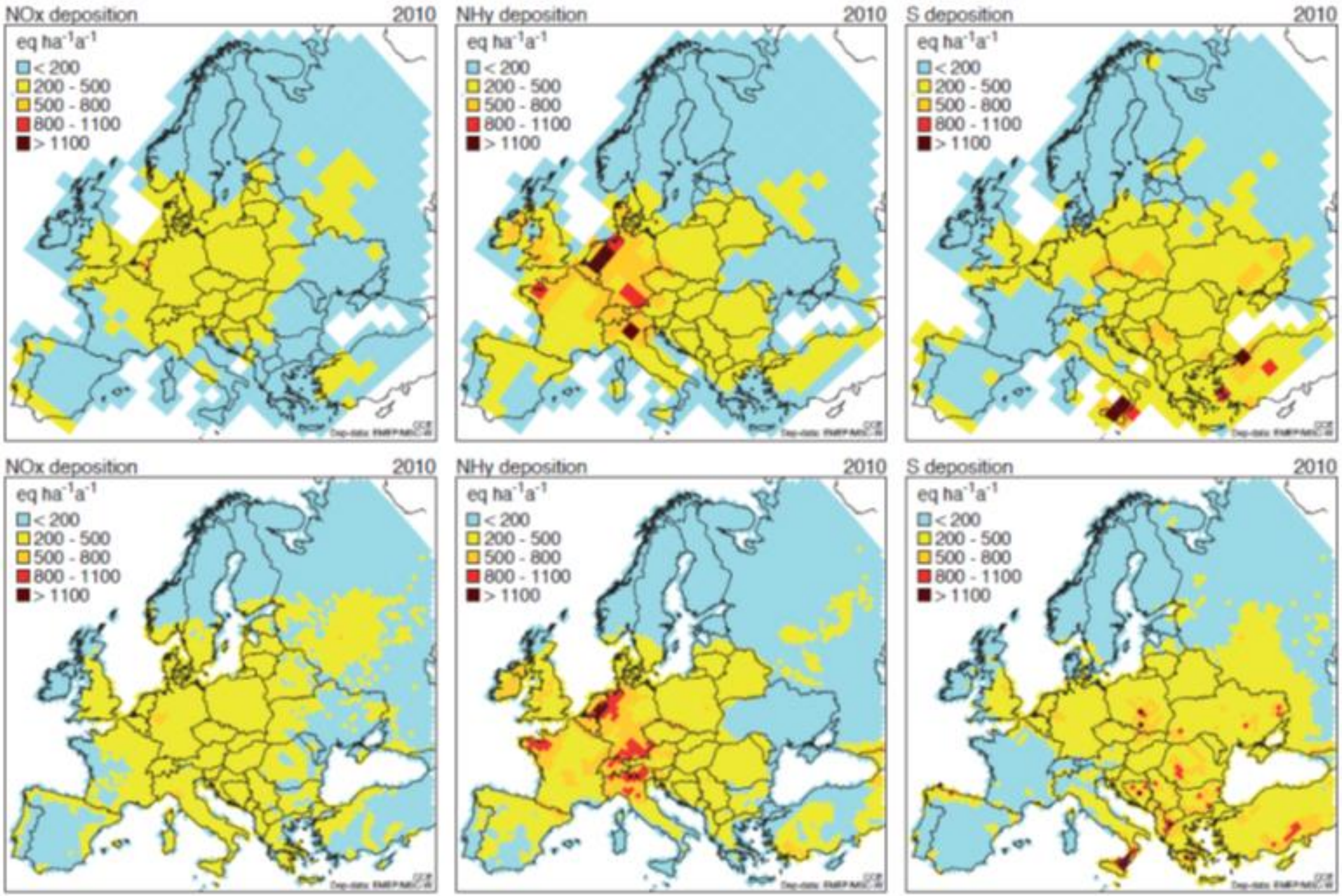
Figure 3.1 Total (wet+dry) 1990 grid-average deposition of NOx (left), NHy (centre) and S (right) (all in eq ha−1a−1) computed with old (lagrangian model; top) and present knowledge (eulerian model; bottom)



Coordination Centre for Effects Status Report 2012

http://wge-cce.org/Publications/CCE_Status_Reports

Figure 3.2 Total (wet+dry) 2010 grid-average deposition of oxidised (left) and reduced (centre) nitrogen, and sulphur (right) computed with old (lagrangian model; top) and present knowledge (eulerian model; bottom)



Coordination Centre for Effects Status Report 2012

http://wge-cce.org/Publications/CCE_Status_Reports

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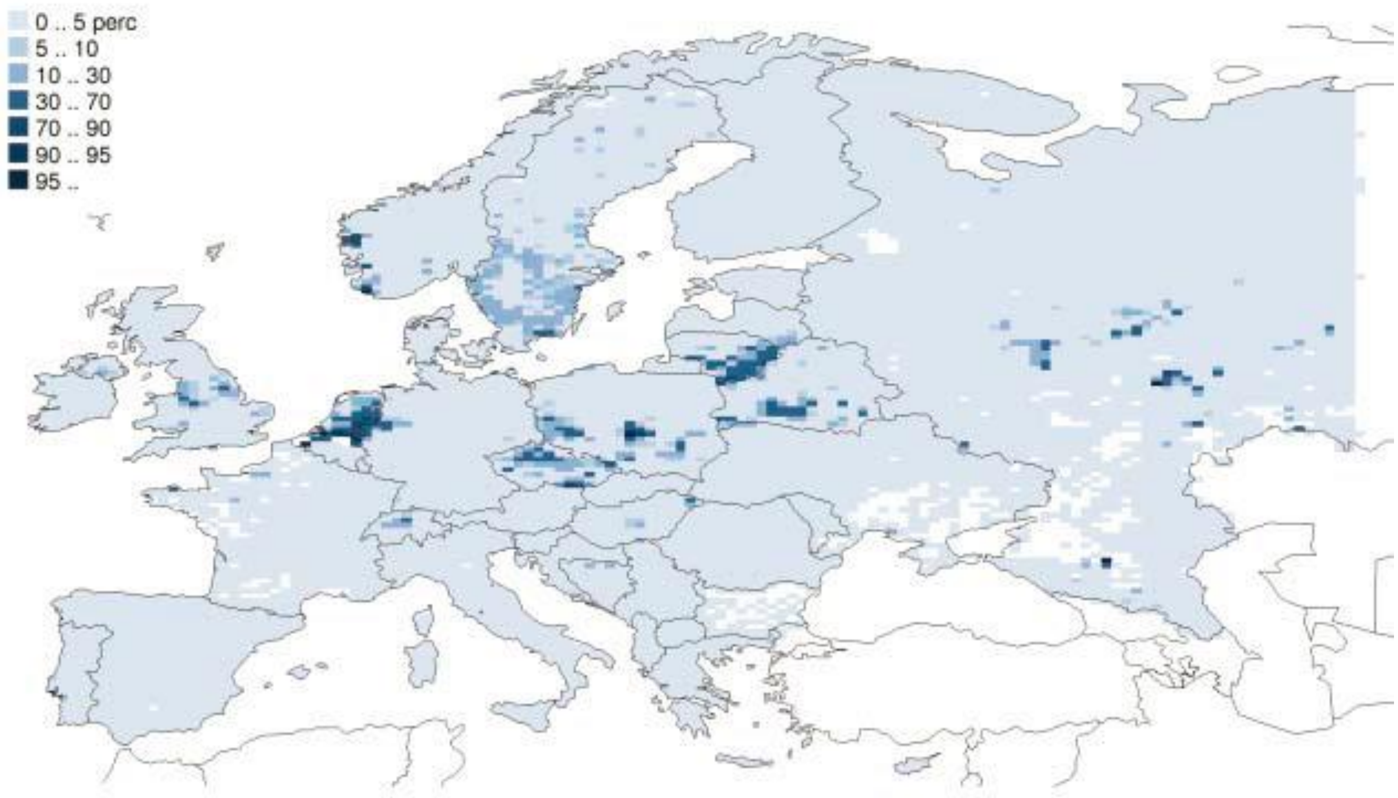
LRTAP
Long-range Transboundary Air Pollution

Acidification



Percentage of forest area with acid deposition above the critical loads for acidification 2030 with Maximum Feasible Reductions

Fig. 3.15. Amann et al. 2014 TSAP 11

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Changing criteria or varying process description changes results

Test: CL of acidification for forest soils, Finland

Test	Model assumptions					Result
	Gibbsite equilibrium	Al-SOM complexes	Leaching of organic anions	Criterion	K_AL_BC	AAE
1	yes	no	no	BC/Al =1		5
2	no	yes	yes	BC/Al =1		4
3	no	yes	yes	BS=30%; 15%	0.01; 0.1	17
4	-	-	no	ANCle=0		25

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Eutrophication

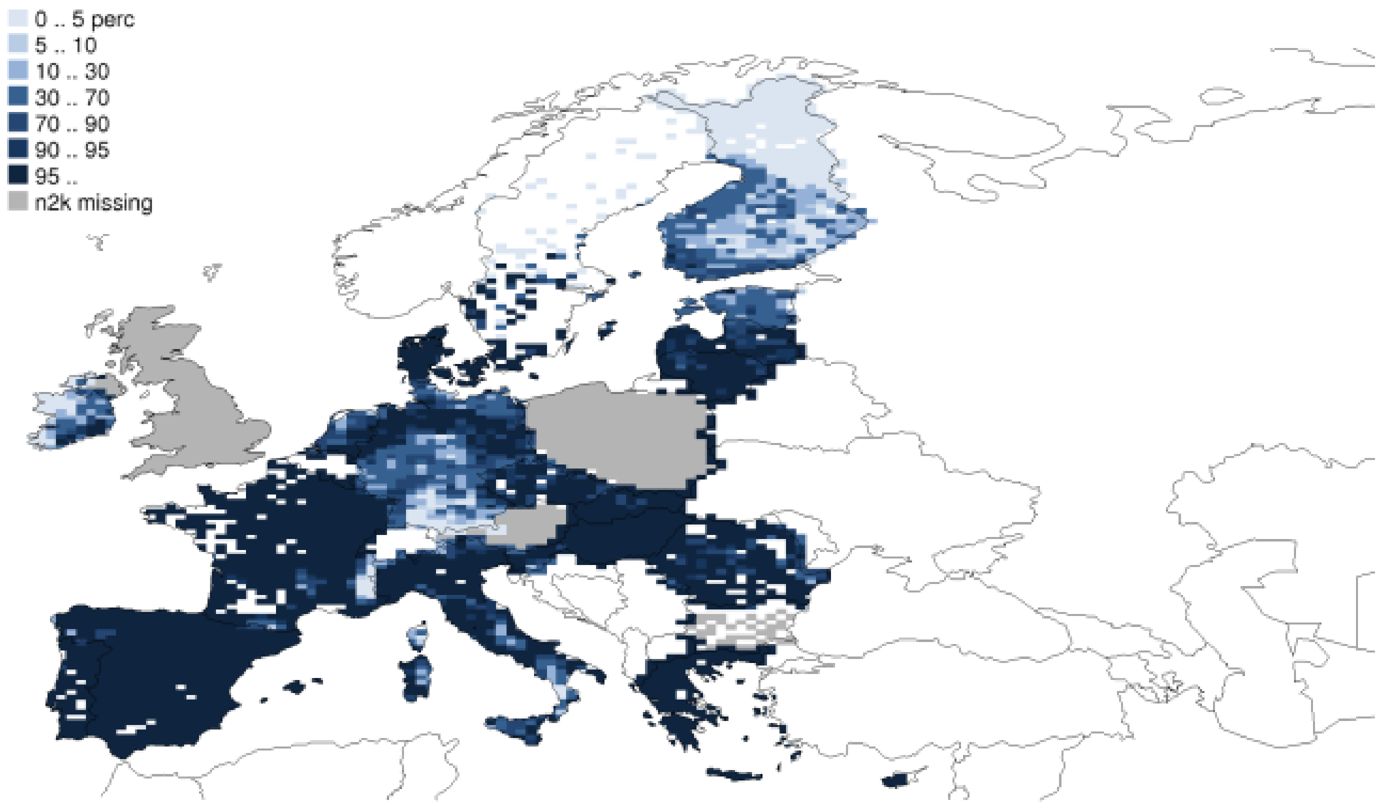

Fig. 3.12. Amann et al. 2014 TSAP 11. Percentage of Natura 2000 areas with nitrogen deposition above their critical limits. Year 2005.

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Eutrophication

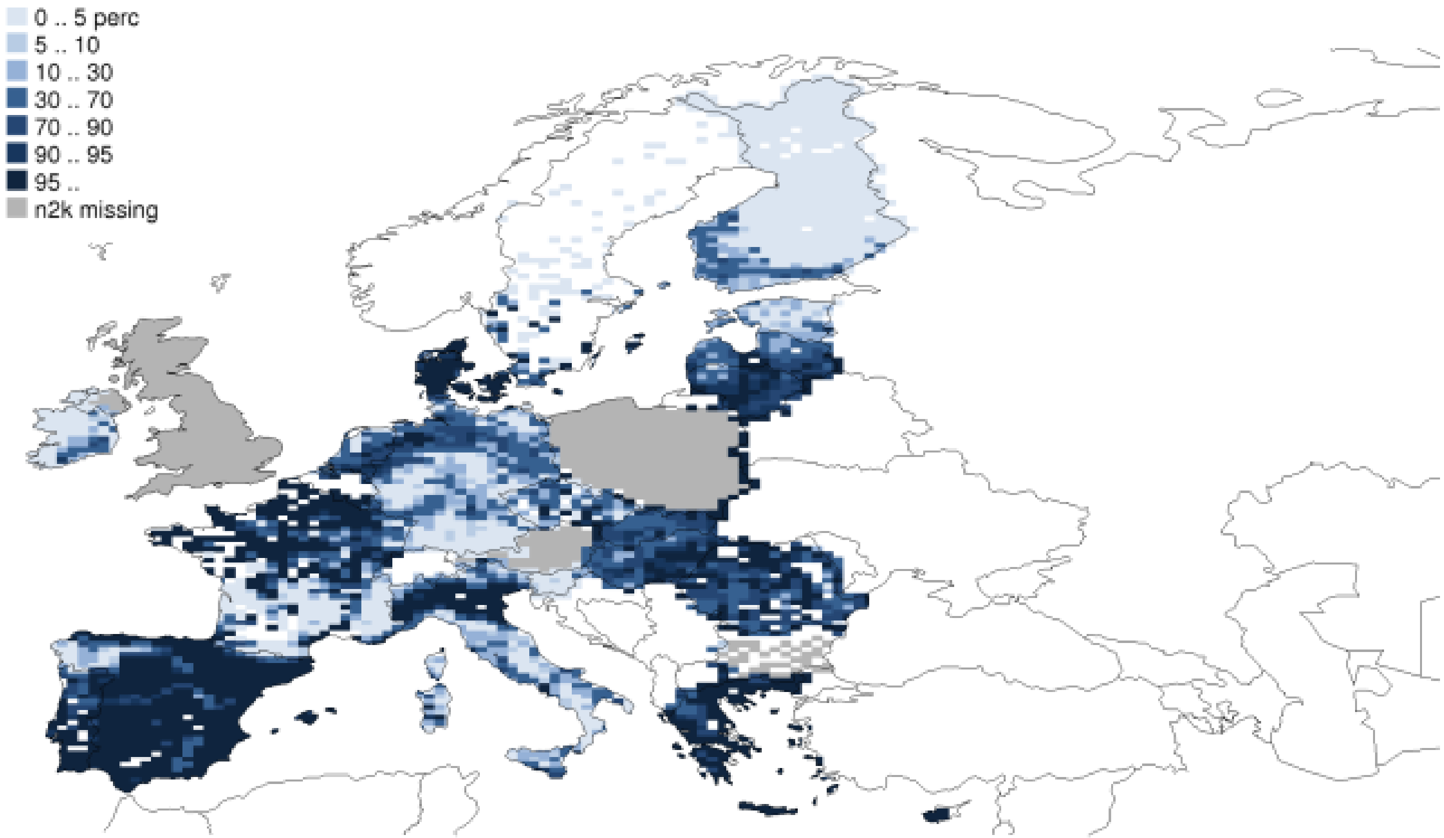

Fig. 3.12. Amann et al. 2014 TSAP 11. Percentage of Natura 2000 areas with nitrogen deposition above their critical limits. Year 2030 with Maximum Feasible Reductions of emissions

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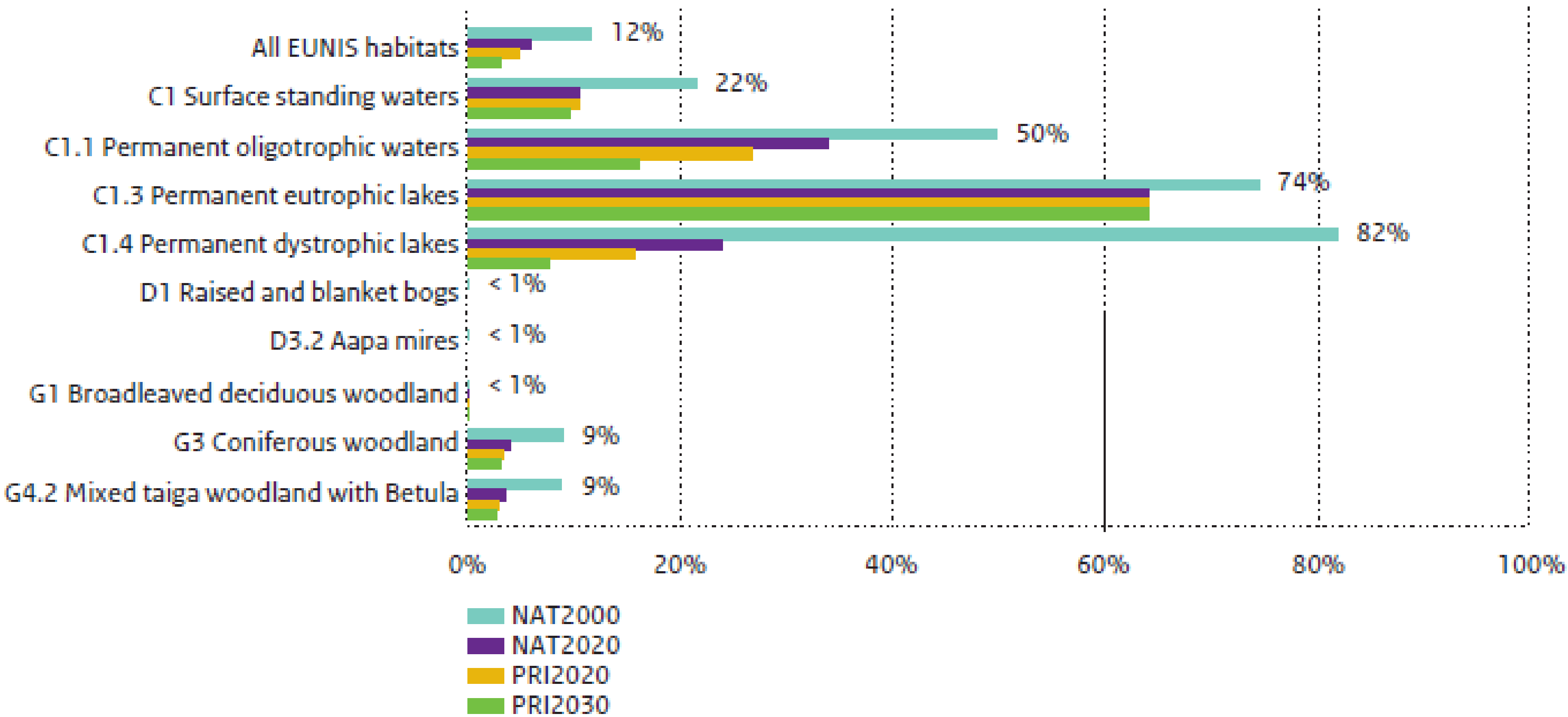
Figure FI.1 Area at risk of eutrophication in Finnish Natura sites, expressed as percentage of total Natura 2000 protected area in each EUNIS class. NAT2000, NAT2020, PRI2020, PRI2030 represent comparisons with different deposition estimates.



ECOS

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Holmberg, M., Leikola, N., Forsius, M., Raunio, A., Katariina, M., Vuorenmaa, J., Salemaa, M. (2011). NFC report Finland. In: Posch, M., Slootweg, J., Hettelingh, J.-P. (Eds.) Modelling critical thresholds and temporal changes of geochemistry and vegetation diversity. CCE Status Report 2011. pp 91-97.

LRTAP Long-range Transboundary Air Pollution

Table FI.1 Empirical CL N values used for Finnish Natura 2000 sites and total area per protection type.

	CLN_{emp}	SPA	SCI	SPA and SCI	Total area in Natura 2000 sites	Area CLN_{emp} exceeded (NAT2000)	AAE (NAT2000)
EUNIS code	kg ha^{-1} yr^{-1}	km^2	km^2	km^2	km^2	km^2	kg ha^{-1} yr^{-1}
A2 Littoral sediments	20	8	3	61	72	0	0
B1Coastal dune and sand habitats	10			0.01	0.01	0	0
B1.3 Shifting coastal dunes	10		1	1	1	0	0
B1.4 Coastal stable dune grassland (grey dunes)	8		0.57	0.24	0.81	0	0
B1.5 Coastal dune heaths	10		0.22	0.06	0.28	0	0
B1.7 Coastal dune woods	10		0.82	0.23	1.05	0	0
B1.8 Moist and wet dune slacks	10		0.02	0.07	0.09	0	0
C1 Surface standing waters	3	14	105	122	241	52	0.30
C1.1 Permanent oligotrophic lakes	3	27	2,893	1,582	4,501	2,233	0.62
C1.3 Permanent eutrophic lakes	3	12	8	11	31	23	1.82
C1.4 Permanent dystrophic lakes	3	100	1,186	235	1,521	1,242	0.87
D1 Raised and blanket bogs	5	28	1,773	2,995	4,796	2	0
D3.2 Aapa mires	5	11	1,536	4,000	5,547	0	0
D4.1 Rich fens	15		4	1	5	0	0
E4.3 Acid alpine and subalpine grassland	5		1	100	101	0	0
F2 Arctic, alpine and subalpine scrub habitats	5		1,506	4,123	5,629	0	0
G1 Broadleaved deciduous woodland	10	4	950	1,389	2,342	1	0
G1.9 Non-riverine woodland with Betula	5		930	1,567	2,497	0	0
G3 Coniferous woodland	5	36	5,770	5,738	11,544	1,046	0.16
G4.2 Mixed taiga woodland with Betula	5	15	674	1,296	1,984	178	0.14
Total area		254	17,340	23,221	40,815	4,776	0.16

Dynamic vegetation modelling at ICP IM sites

EU No Net Loss of Biodiversity

- Biodiversity threatened by multiple stressors including
  - Nitrogen (N) pollution, climate change, land use
  - Rate of loss of biodiversity not slowing down
  - Pressures increasing

    (Butchart et al. 2010)
- EU Biodiversity strategy 2011
- EU No Net Loss Initiative expected 2015

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Dynamic vegetation modelling at ICP IM sites

Role of N deposition in loss of biodiversity

- N emissions stabilized or increased slightly

  Amann et al. 2013

- Long term impacts of N deposition on biodiversity identified and likely to continue under projected deposition levels

  Bobbink et al. 2010

  Dirnböck et al. 2014

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LRTAP Long-range Transboundary Air Pollution

Dynamic vegetation modelling at ICP IM sites

Preprocessing

- Methyd
  - Climate : T,P
  - Soil moisture
  - Modifying factors: mineralisation, nitrification
- GrowUp
  - Uptake of N and BC
  - Input of C and N to soil

Calibrate VSD+ using observations, observed deposition and scaled historic deposition

- Observed:
  - Soil BS, C, N
  - Solution pH, ANC, SO4, Al, etc.

Run

VSD+ using calibrated parameters and scaled future deposition

- Results:1995 to 2030
  - pH
  - C, N
  - Temperature
  - Precipitation

Run

PROPS in VSD+ using VSD+ results and P

- Results: 1995 to 2030
  - Species
  - Species cover
  - Diversity index
- BERN
  - Habitat suitability

Location of UNECE/ WGE/ ICP IM sites..

January 2014

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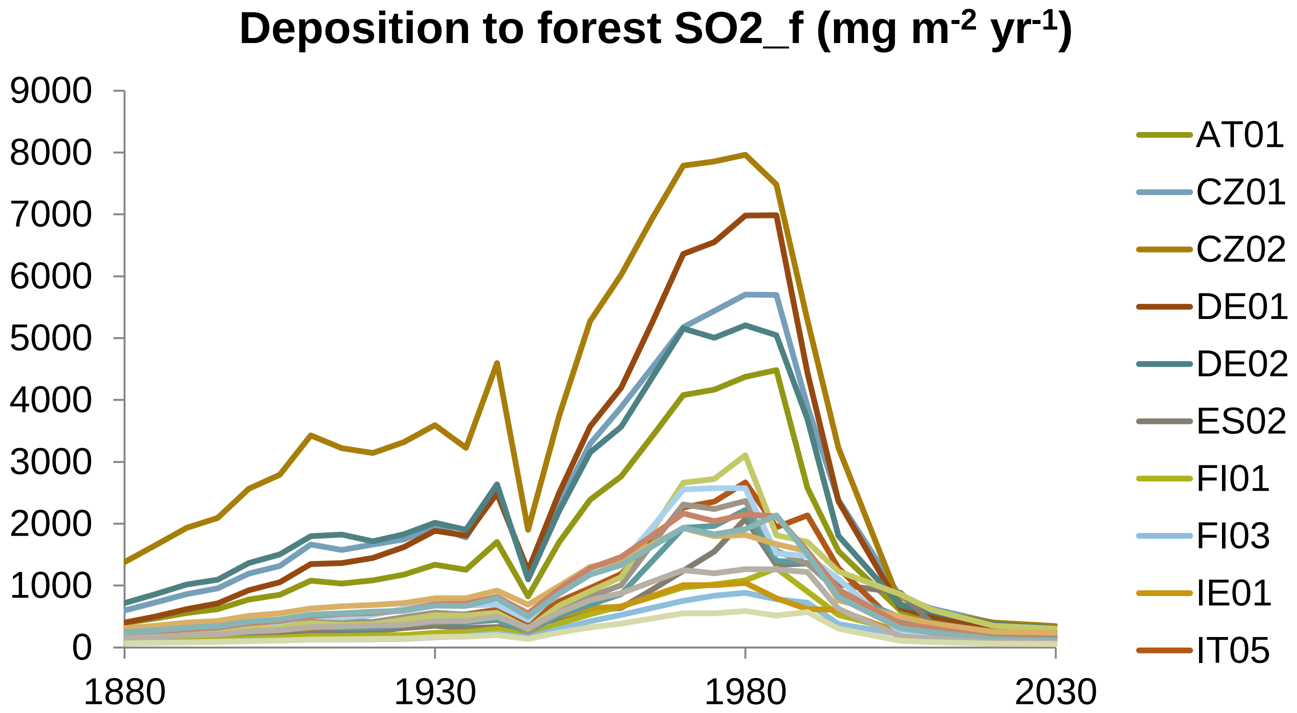
Decline in sulphur deposition



Historic deposition Schöpp et al. 2003, Future deposition based on latest EMEP model version Simpson et al. 2012 using the current legislation scenario (CLE) with revised Gothenburg Protocol emissions.

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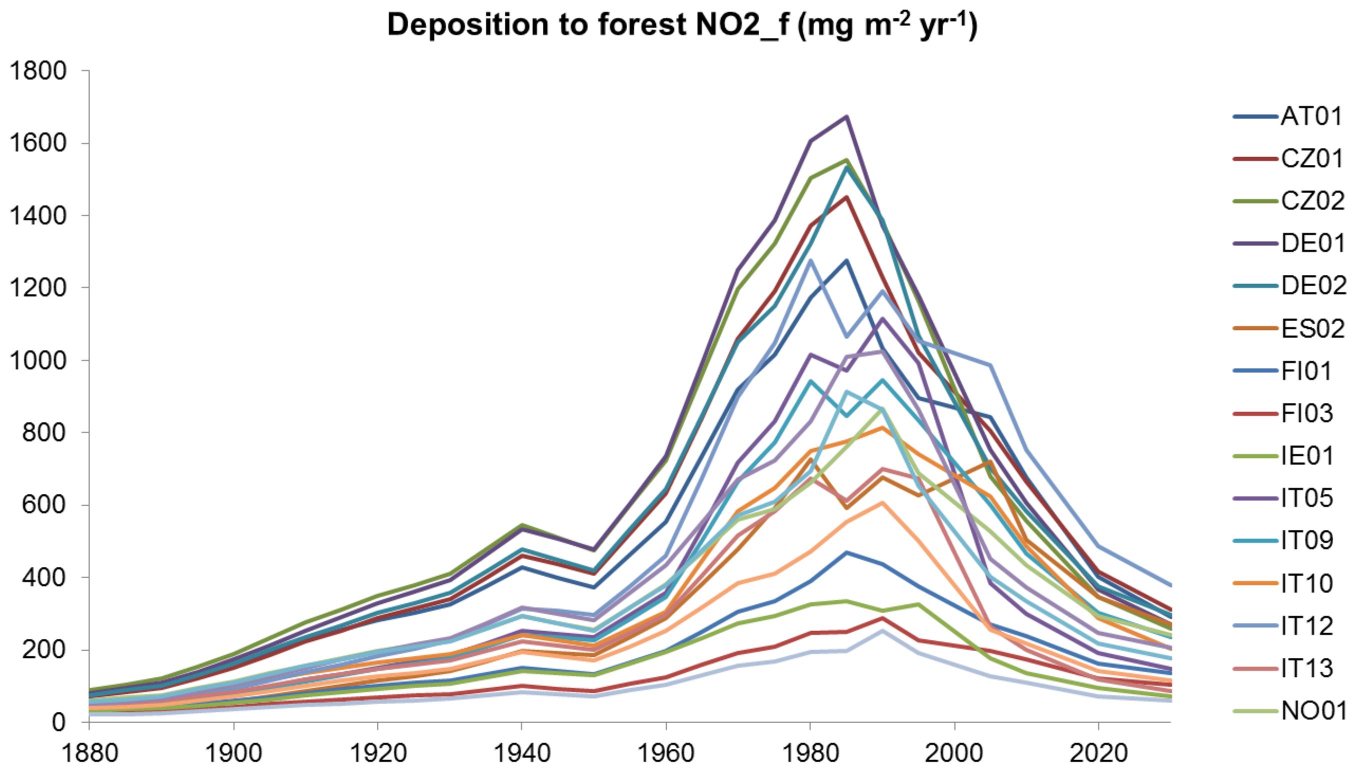
Nitrogen deposition continues



Historic deposition Schöpp et al. 2003, Future deposition based on latest EMEP model version Simpson et al. 2012 using the current legislation scenario (CLE) with revised Gothenburg Protocol emissions.

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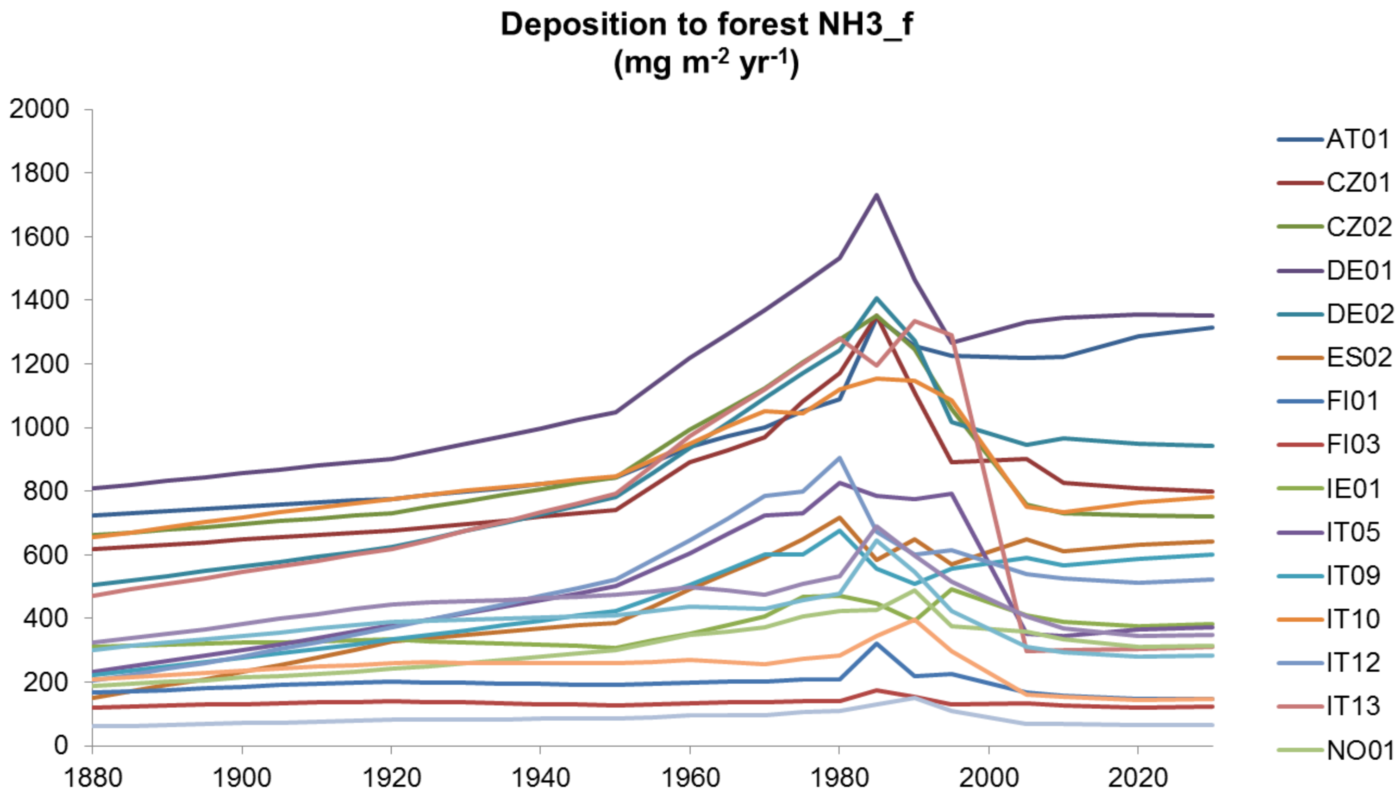
Nitrogen deposition continues



Historic deposition Schöpp et al. 2003, Future deposition based on latest EMEP model version Simpson et al. 2012 using the current legislation scenario (CLE) with revised Gothenburg Protocol emissions.

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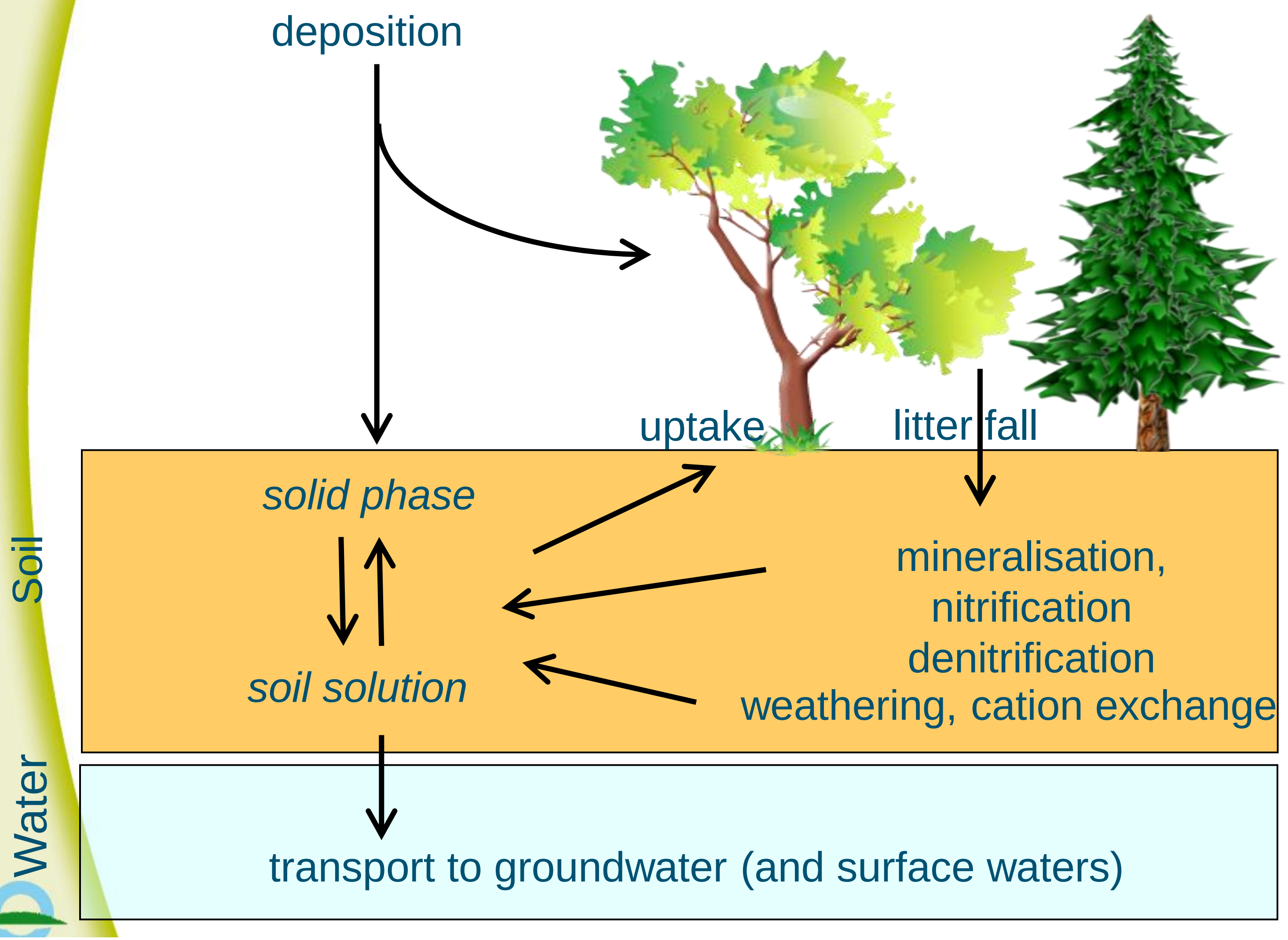
VSD+



http://wge-cce.org/Methods_Data/The_VSD_suite_of_models

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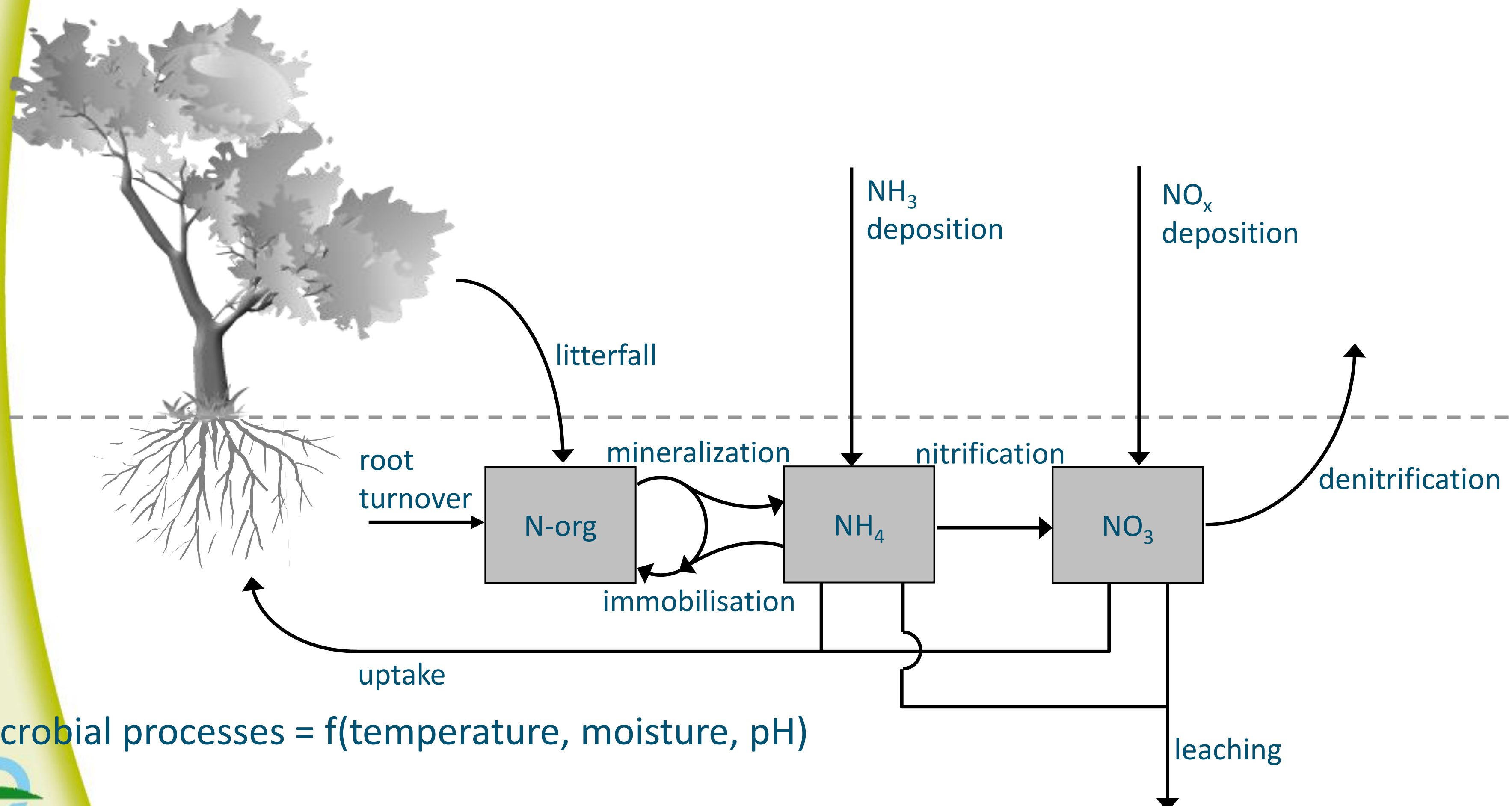
N processes in VSD+



microbial processes = f(temperature, moisture, pH)

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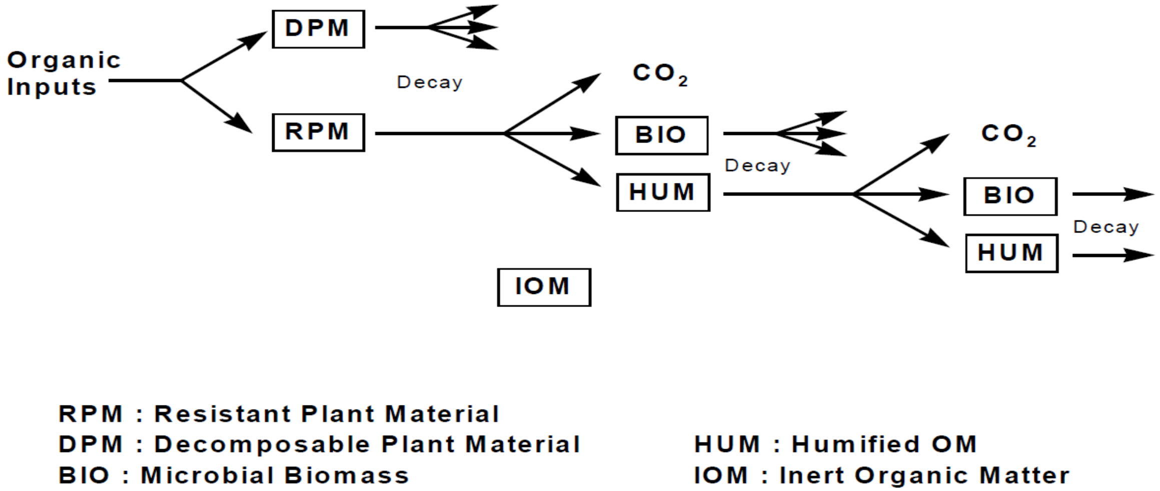
http://wge-cce.org/Methods_Data/The_VSD_suite_of_models

RothC model

C pools:

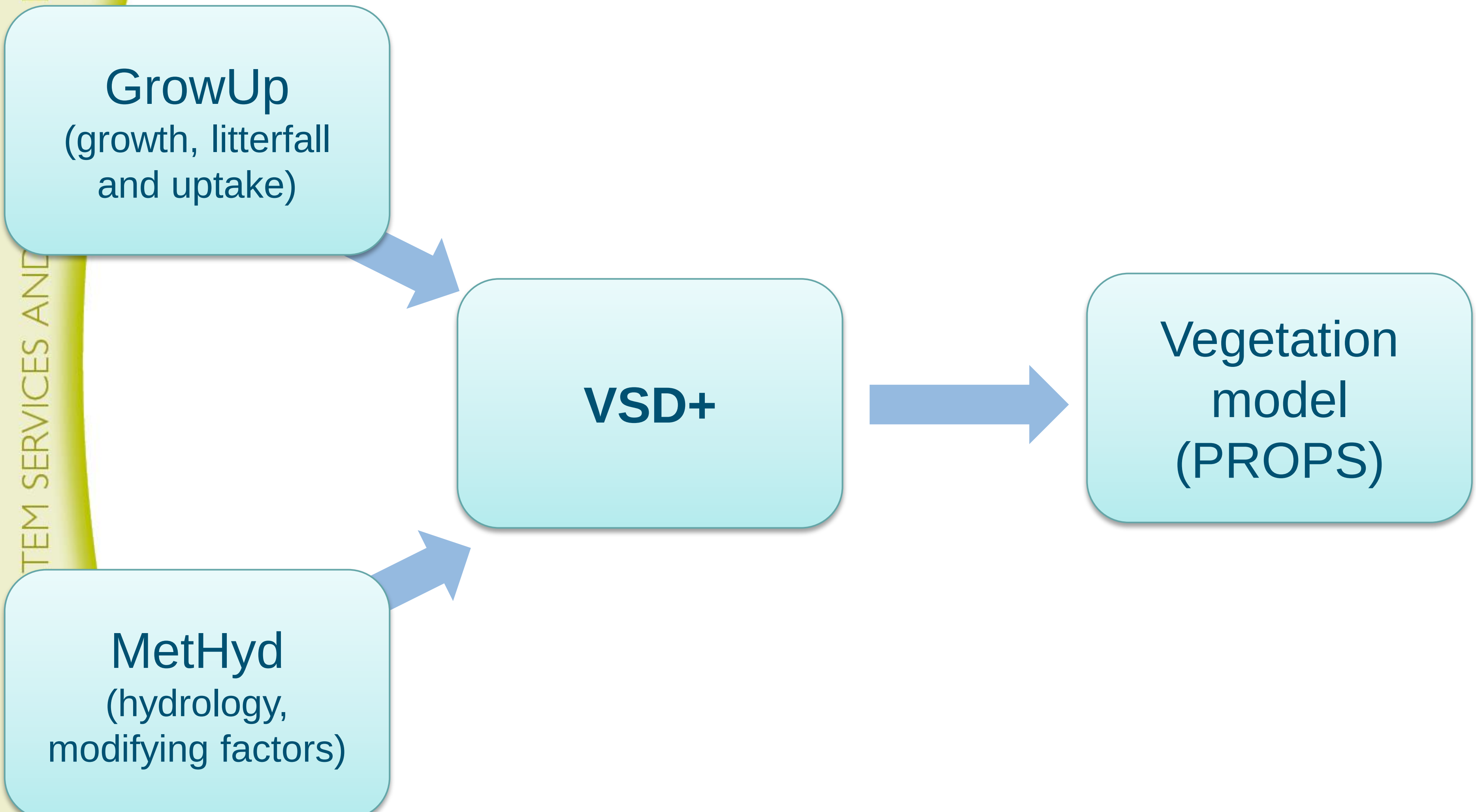


N dynamics:

- fixed N contents for DPM, RPM and BIO
- $N_{HUM} = f(N_{DPM}, f_{RPM}, f_{BIO})$, but is reduced when N uptake > N deposition + N mineralisation

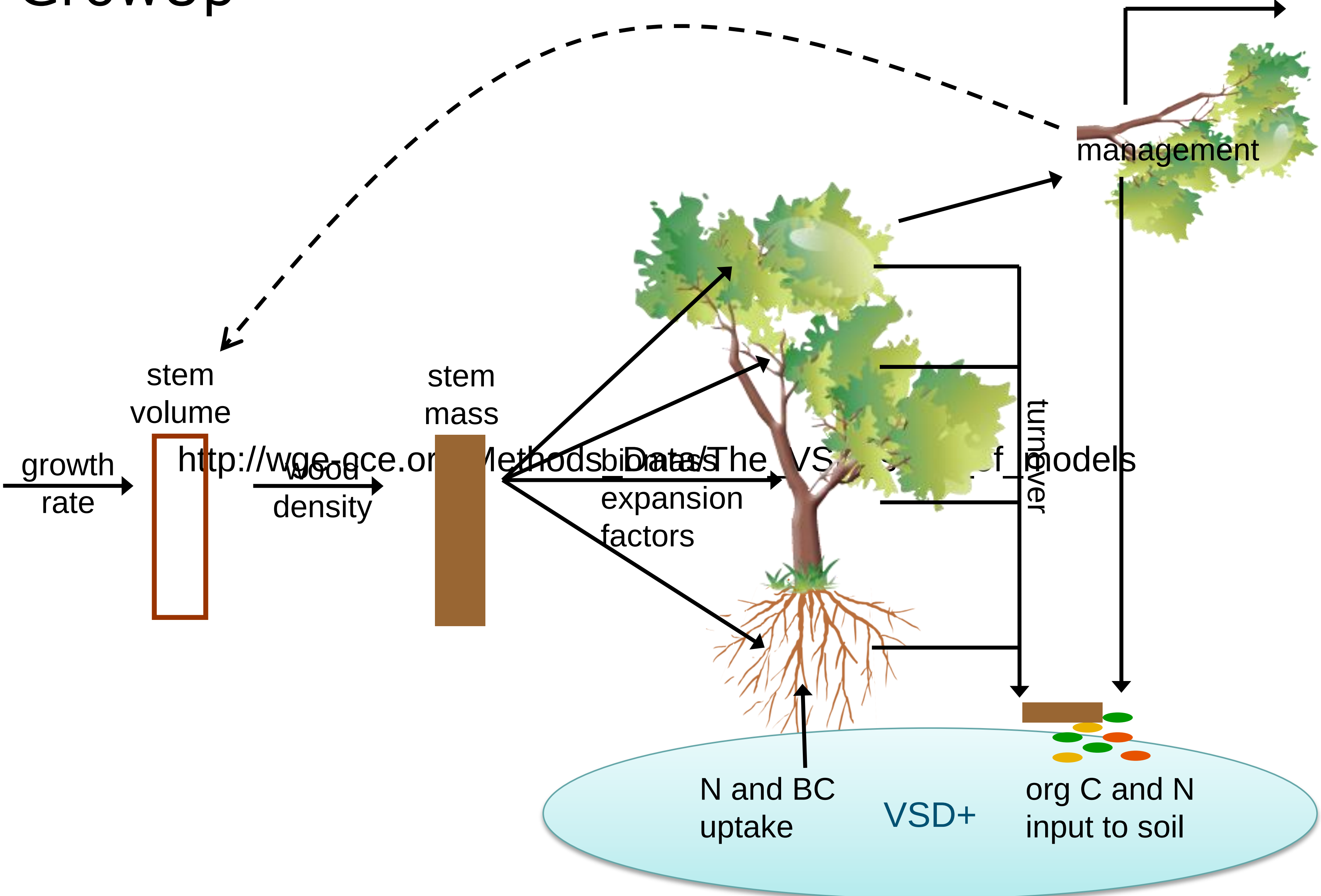
http://wge-cce.org/Methods_Data/The_VSD_suite_of_models

VSD+ tool set



http://wge-cce.org/Methods_Data/The_VSD_suite_of_models

GrowUp



http://wge-cce.org/Methods_Data/The_VSD_suite_of_models

PROPS – PRObability of Plant Species

- calculates the chance/probability/suitability that a plant species is present (not abundance!)
- based on measured/measurable abiotic conditions

Derived from:

- relevés with simultaneously measured abiotic conditions (N, pH)
- climate data

http://wge-cce.org/Methods_Data/The_VSD_suite_of_models

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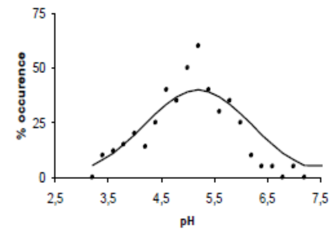
Suggested indicator:
Habitat Suitability

5

Calculating Endpoint

PROPS for 80% species



Chance of occurrence

Suitability = Chance of occurrence / Maximum chance

Averaged over species

Overall Suitability for high quality =

Suitability/ maximum suitability (maximum in history/future)

Arjen van Hinsberg, UNECE/WGE/ICP M&M workshop April 2014

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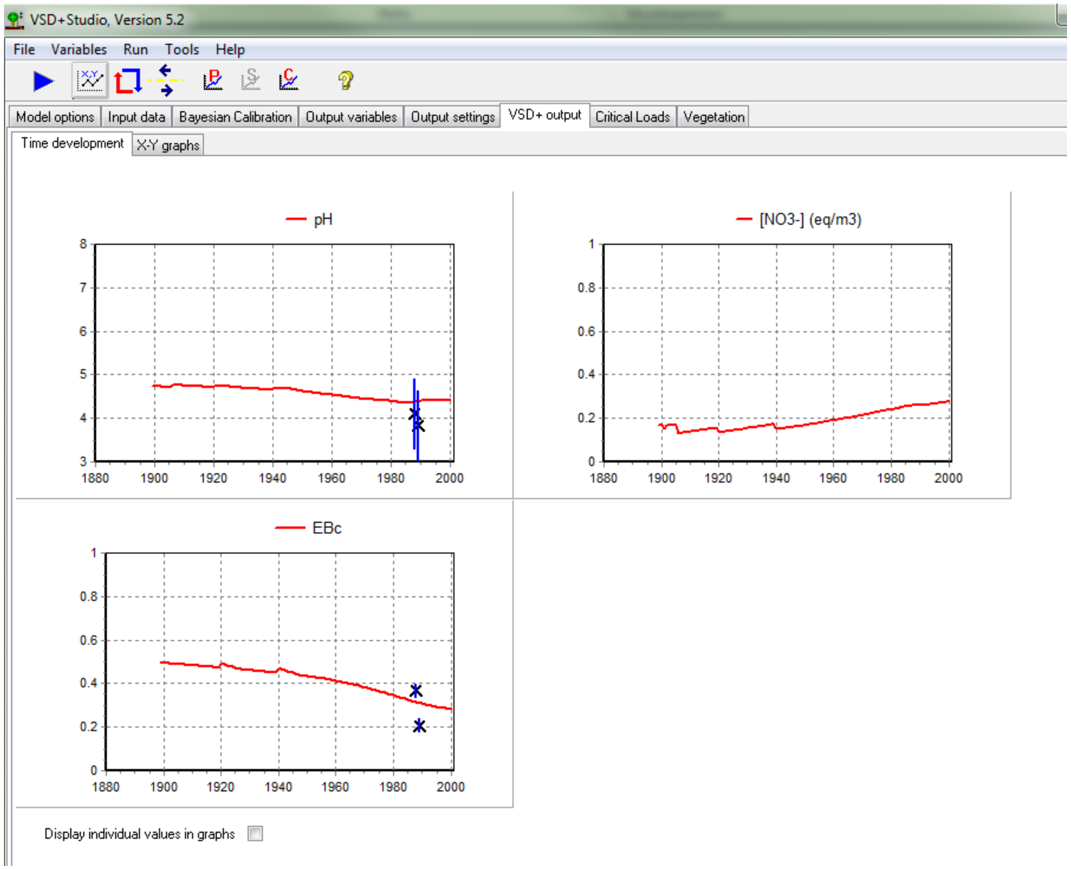
VSD + applied at Valkea-Kotinen, southern Finland



Work in progress!

Soil pH stabilizes, NO3 increases, soil exchangeable base cations decrease

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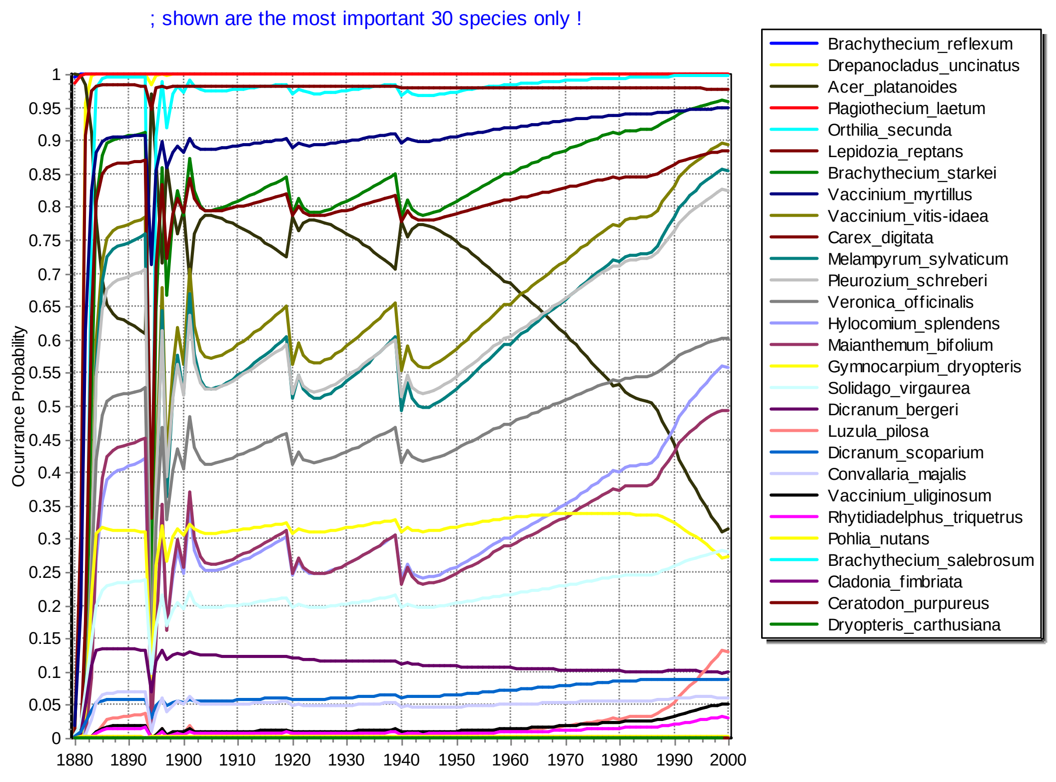
Application of VSD+ with PROPS to Valkea-Kotinen, southern Finland



Species cover of 30 species at Valkea-Kotinen

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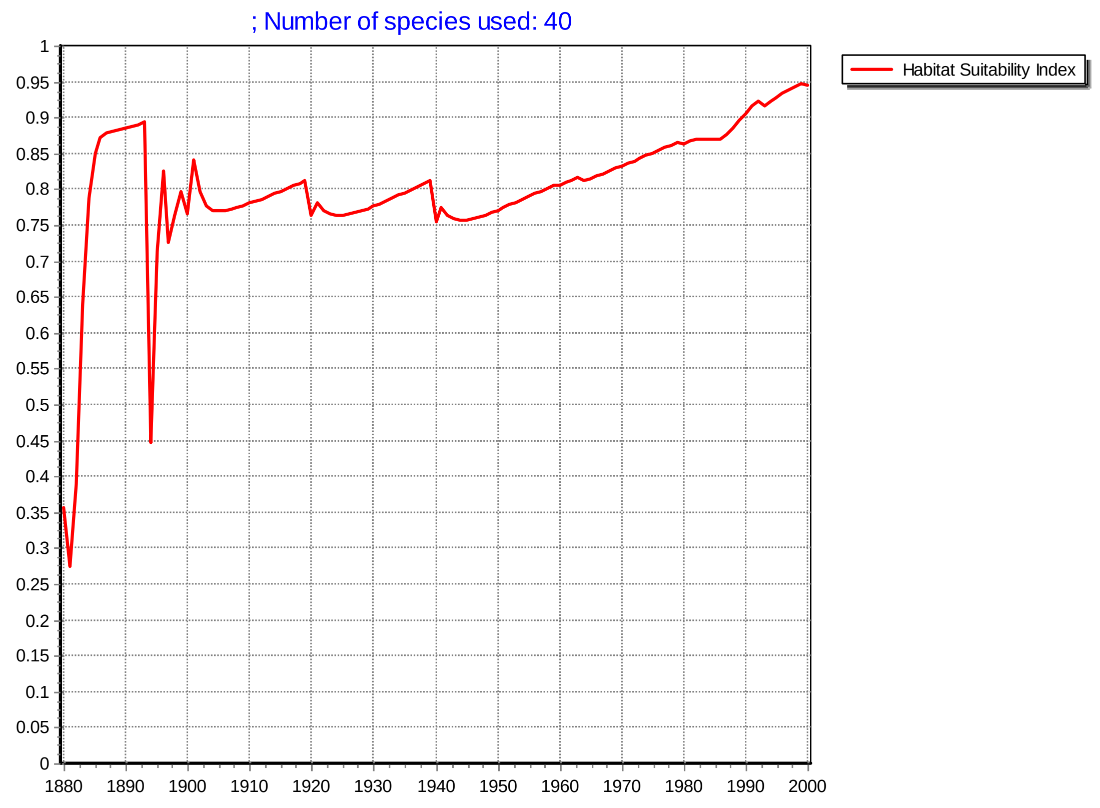
Application of VSD+ with PROPS to Valkea-Kotinen, southern Finland



Habitat suitability index

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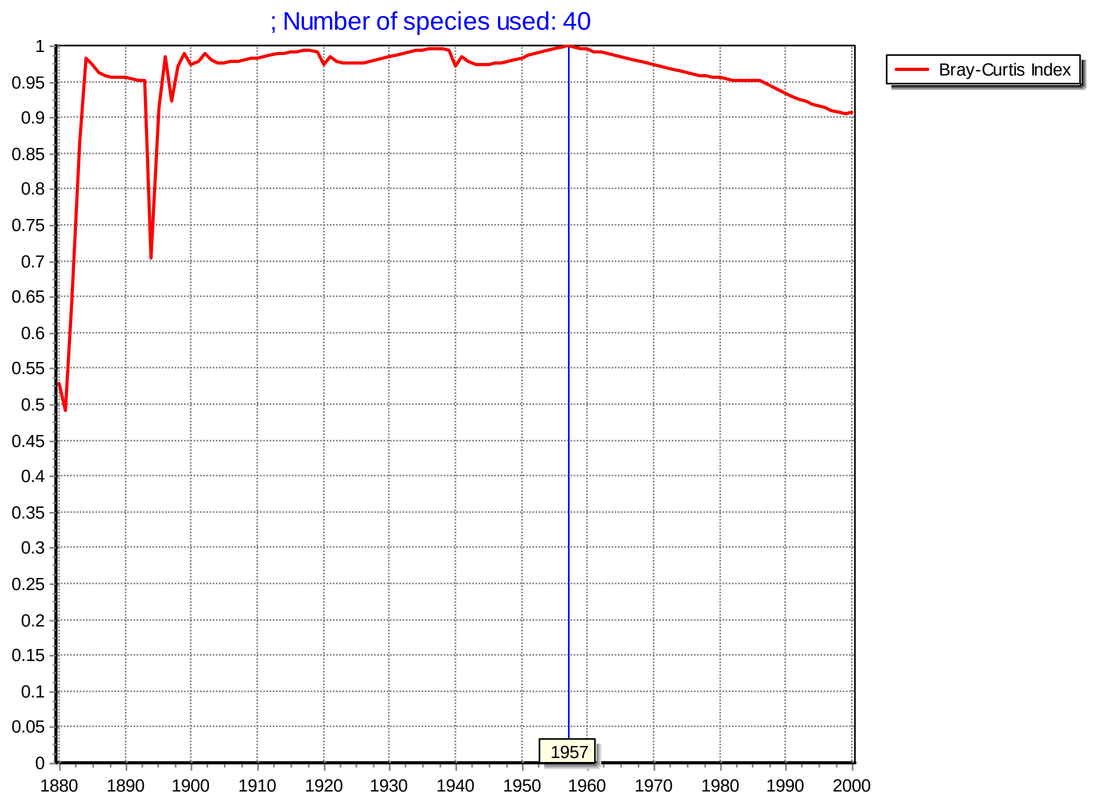

Bray-Curtis index

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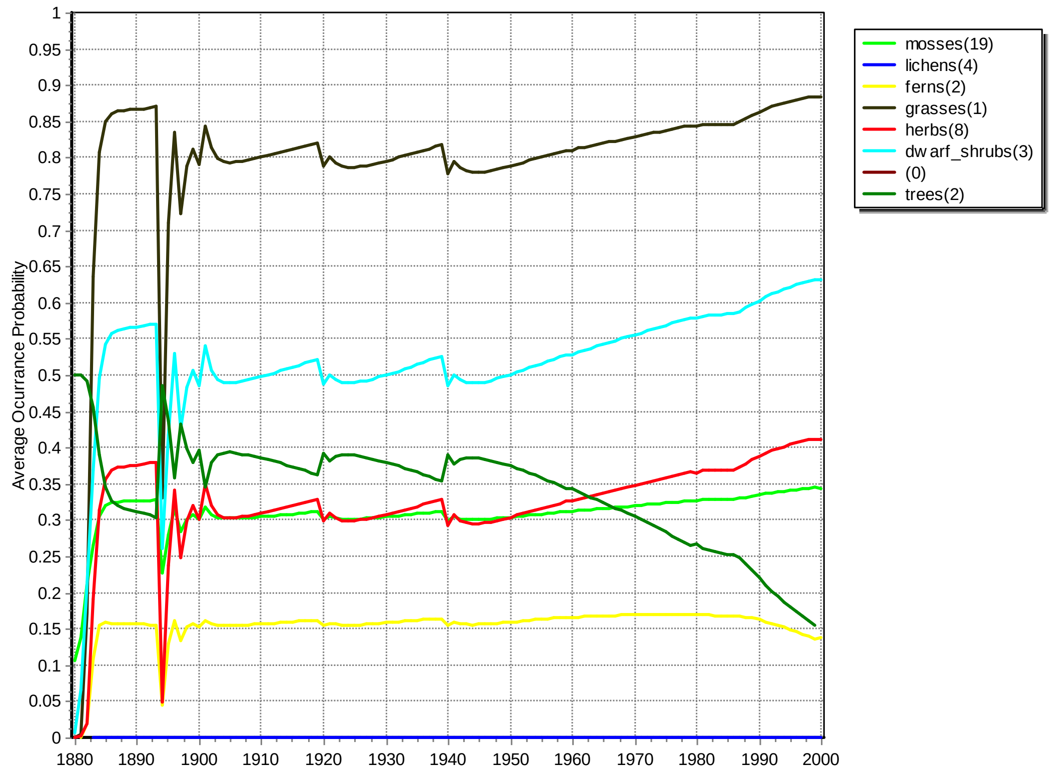
Application of VSD+ with PROPS to Valkea-Kotinen, southern Finland



Species groups

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Key challenges in finding sustainable future

- Defining key features of the system
  - Variables, indicators
  - *Who defines the indicators?Society, scientists, stakeholders?*
- Selecting reference conditions
  - Critical thresholds
  - *Who defines the reference state? Society, scientists, stakeholders?*
- Communicating methods, aims and results
  - Across disciplines: natural and social sciences
  - Within society: laymen, media, experts, scientists, decision makers
  - How to improve communication?

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Thank you for your attention!

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LRTAP Long-range Transboundary Air Pollution