Für Mensch & Umwelt

Umwelt Bundesamt

37TH TASK FORCE MEETING, 28TH CCE WORKSHOP & 2ND CDM MEETING

Review & Revision of Empirical Critical Loads for Nitrogen

Christin Loran, Roland Bobbink, Laurence Jones, Chris Field, Carly Stevens, Leon van den Berg, Sabine Braun, Markus Geupel & many more

Web-Conference, 20 – 22 April 2021

General overview

- Review and revision of CLempN is coordinated by CCE
- Duration: Summer 2020 – Spring 2022
- Funding: CCE / NFCs

Time frame 2020 – 2022

General overview

- Process coordinated by CCE
- Duration: 2020 – 2022
- Funding: CCE / NFCs

- 06/2020: Virtual Kick-off Meeting *(58 participants)*
- 06/2020 – 06/2021: **45 authors** updating the chapters *(Bobbink et al. 2011)*

  ›› Last revision 2011: 7 authors

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- 07/2021 – 09/2021: Review round of the chapters by external experts

→ Experts who are interested in participating are welcome to contact CCE@uba.de (latest by mid May 2021)

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- 10/2021: Expert workshop over 3 days (26.-28.) in Switzerland: Determination of revised CLempN

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- 11/2021 – 04/2022: Completion and publication of the new report on CLempN

CHAPTER

Updating and reviewing procedure for CLempN

Roland Bobbink,

Julian Aherne,
Rocío Alonso,
Sabine Braun,
Chris Field,
Laurence Jones,
Lukas Kohli,
Christin Loran,
Reto Meier,
Filip Moldan,
Anne-Katrin Prescher,
Ed Rowe,
Kai Schwärzel,
Carly Stevens

Updating and reviewing procedure for CLempN

Updating and reviewing procedure for CLempN

- Two major types of "empirical" evidence available to relate atmospheric N deposition to changes in structure and/or function of ecosystems:

1) Long-term field addition (or manipulation) experiments

2) **Gradient studies *(have been incorporated as important insights)***
   - ➢ Advantages are for example:
     - May provide information on longer-term responses
     - Cover a more differentiated range of N deposition
     - Avoid experimental artefacts and allow to analyse interactions with other environmental stressors (e.g. drought)
   - ➢ Disadvantages are for example:
     - Greater variability in ecological response, which requires careful consideration of confounding variables → careful and appropriate design and statistical evaluation

CHAPTER

Marine habitats (EUNIS class A)

Roland Bobbink

CHAPTER

Coastal habitats (EUNIS class B)

Laurence Jones,

Eva Remke

Chapter - Coastal habitats

Shifting coastal dunes B1.3

- Few new studies, except +5 kgN x plastics on embryo dunes in Mediterranean (Maricagli et al. 2020)

Coastal stable dune grasslands B1.4

- New gradient studies, UK (Pakeman et al. 2016)

Coastal dune heaths B1.5

- Some new work, data suggest different from author conclusions (Bähring et al 2017)

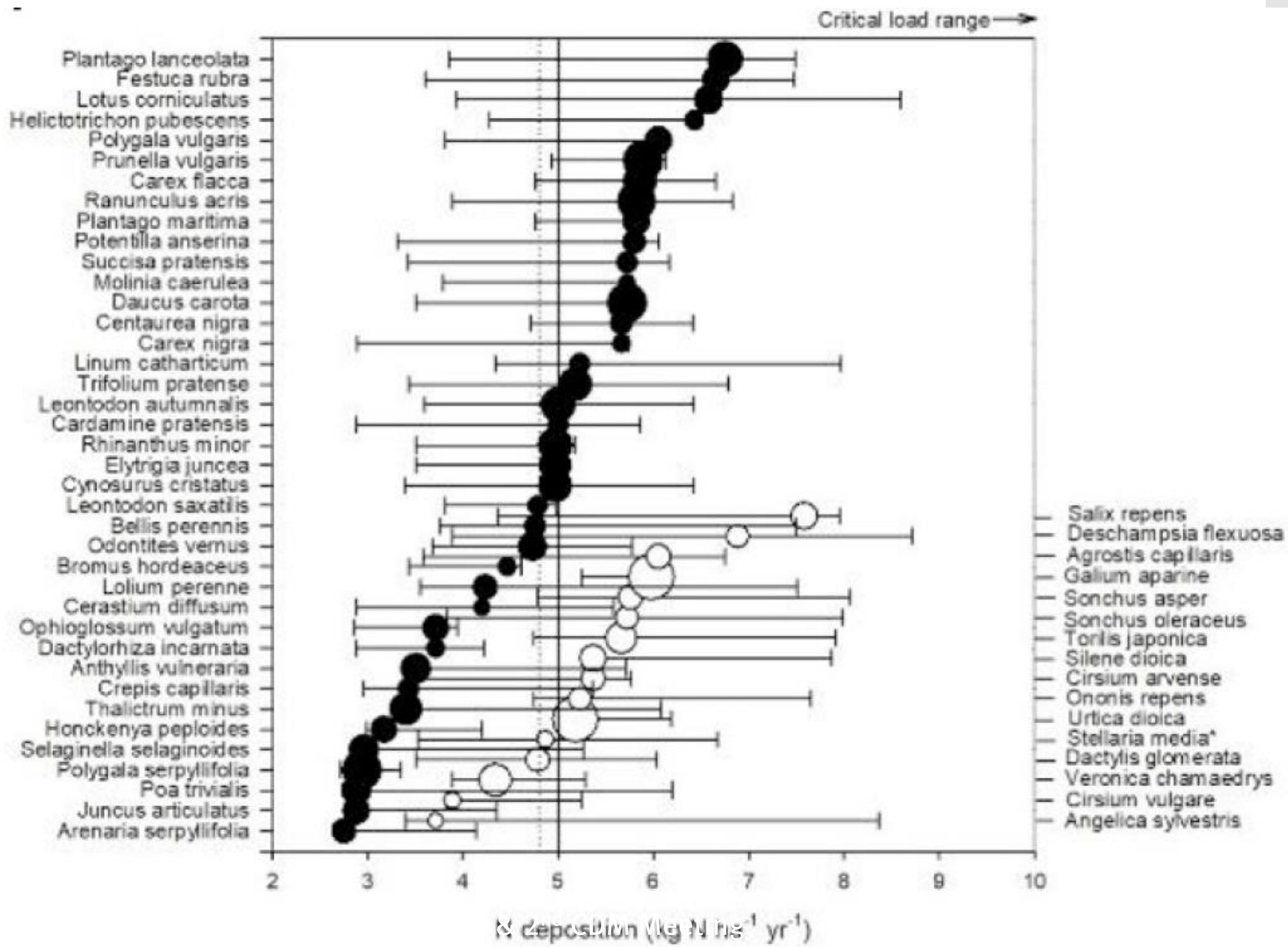
Moist to wet dune slacks B1.8

- New gradient studies UK (Payne et al. 2020)

Coastal stable dune grasslands

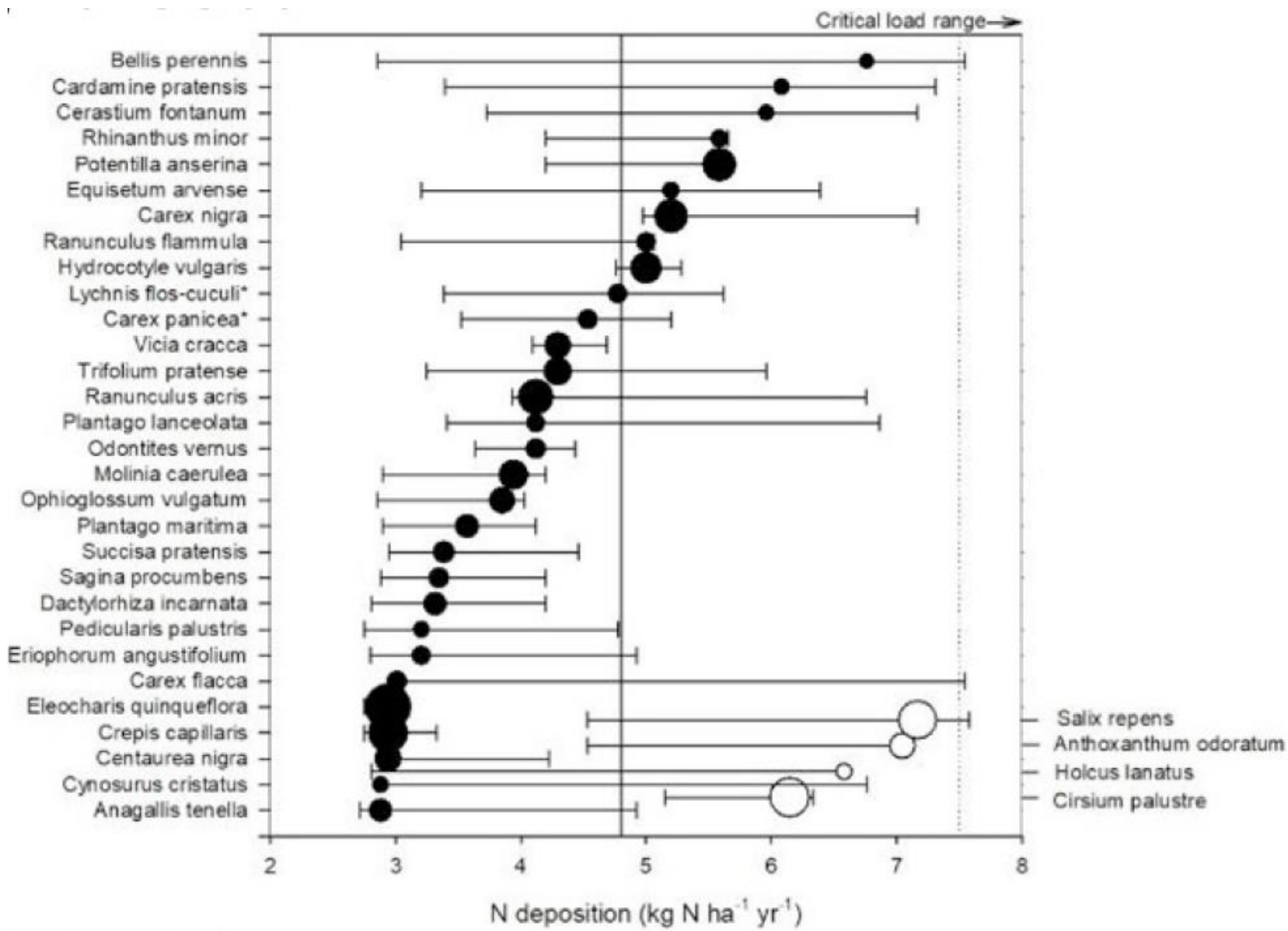
Scottish coastal vegetation over 35 year interval (1975-2010), showed increased fertility of fixed dune grassland, from mean Ellenberg N score of 4.003 to 4.195 over time (Pakeman et al. 2016)

(Payne et al. 2020)



Moist to wet dune slacks

(Payne et al. 2020)



Interim suggested changes to critical loads (Preliminary only)

Ecosystem type	EUNIS code	kg N ha^{-1} yr^{-1}	Reliability	Indication of exceedance
Shifting coastal dunes	B1.3	10-15	(#)	Biomass increase, increase N leaching; reduced root biomass
Coastal stable dune grasslands (grey dunes)[a]	B1.4	**5-15**	#	Increase tall graminoids, decrease prostrate plants, increased N leaching, soil acidification, loss of typical lichen species
Coastal dune heaths	B1.5	10-15	(#)	Increase plant production, increase N leaching, accelerated succession, typical lichen C/N decrease, increase yearly increment Calluna...
Moist to wet dune slacks[b]	B1.8	**5-15**	#	Decrease in some species, increase in others; increased Ellenberg N

CHAPTER

Inland surface waters (EUNIS class C)

Christin Loran / Roland Bobbink,

Emiel Brouwer,
Heleen De Wit,
Linda May,
Jan-Erik Thrane

Subchapters on surface standing waters

- **Atlantic soft water lakes (Linda May)**
  - Literature review completed
  - Very view relevant studies → CLempN remain the same
  - Improving the text of the chapter

- **Dune slack pools (Emiel Brouwer)**
  - Literature review completed
  - Very view relevant studies → CLempN remain the same
  - Improving the text of the chapter: highlighting ecosystem functions for example

- **Oligotrophic boreal and alpine lakes (Heleen de Wit, Jan-Erik Thrane)**
  - Literature review & data analysis is still ongoing

    (ICP Waters: update of the nitrogen report 2020-2021)

CHAPTER

Mires, bogs and fens (EUNIS class D)

Chris Field,

Julian Aherne,
Roland Bobbink,
Hilde Tomassen

Chapter - Mires, bogs and fens

EUNIS D IS NOW EUNIS Q!	LAST TIME:
Q1 (D1) Raised And Blanket Bogs	(CL RANGE 5-10), NOT SPLIT BY BOG TYPE
Q2 (D2) Valley Mires, Poor Fens And Transition Mires	(CL RANGE 10-15)
Q3 (D3) Palsa And Polygon Mires	(NO CL)
Q4 (D4) Base-rich Fens And Calcareous Spring Mires	(CL RANGE 15-30)
Q5 (D5, D6) Helophyte Beds	(NO CL) - N ENRICHMENTS NOT OBSERVED IN SEVERAL OPEN WETLAND SYSTEMS

Literature searching

- 975 papers reviewed across all habitats from 2010-2019
- 67 of these shortlisted to EUNIS Q and associated vegetation
- Further literature review of 2019-2021 produced another 36 papers
- Of these 103 papers:

- 52 Q1 raised and blanket bogs, almost all Q1.1
- 8 Q2 mainly poor fens
- 5 Q4 rich fens

+ A thesis for Q3 Palsa and Polygon Mires written in French!

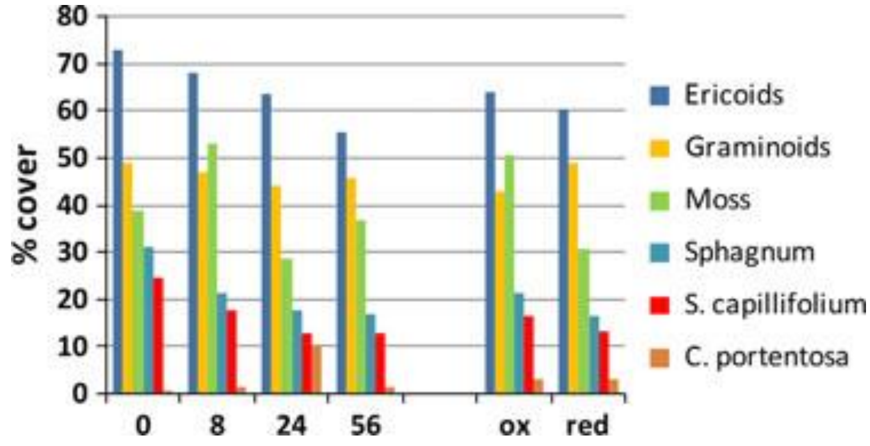
Some papers covered multiple habitats, others proved not useful

Next step is to review these 64 papers in detail against criteria

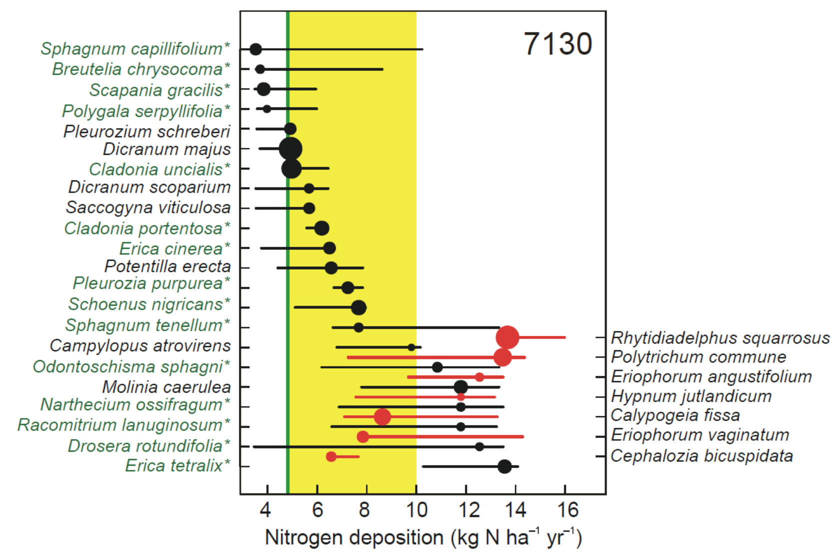
31 EU
18 Canada
7 China
2 US
6 multiple

Notable literature

- Several papers from the CEH Whim Moss experiment led by Lucy Sheppard
- TITAN Analysis of Irish vegetation (Aherne, Wilkins and others)
- Gradient study of Dutch fens (van Diggelen et al 2018 – awaiting translation!)
- A number from Canada – may not be suitable
- UK JNCC Collation report
- UK Gradient study and 'Thresholds' report



Sheppard et al 2014



Wilkins et al 2018

CHAPTER

Grasslands and lands dominated by forbs, mosses or lichens (EUNIS class R)

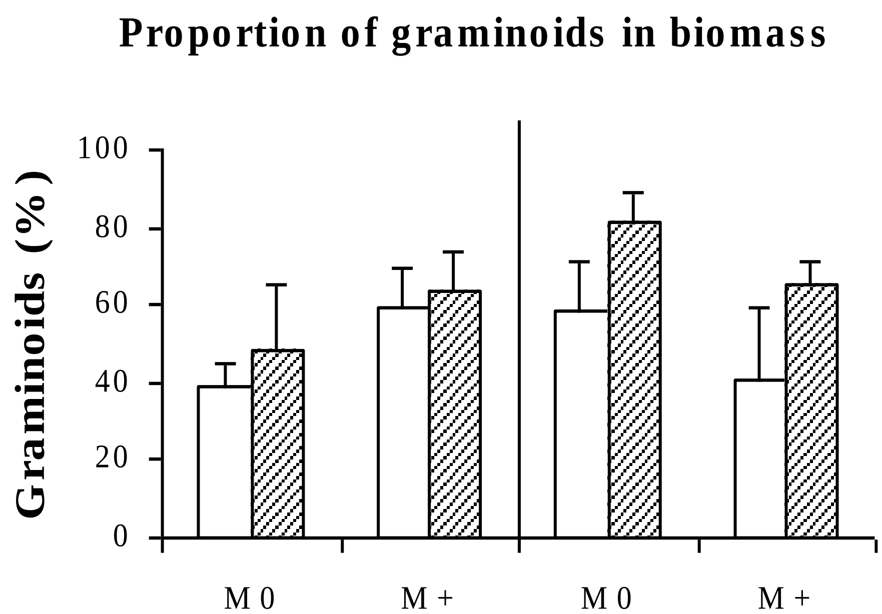
Carly Stevens,

Rocío Alonso,
Vegar Bakkestuen,
Felicity Hayes,
Erika Hiltbrunner,
Lukas Kohli,
Tobias Roth

Grassland communities

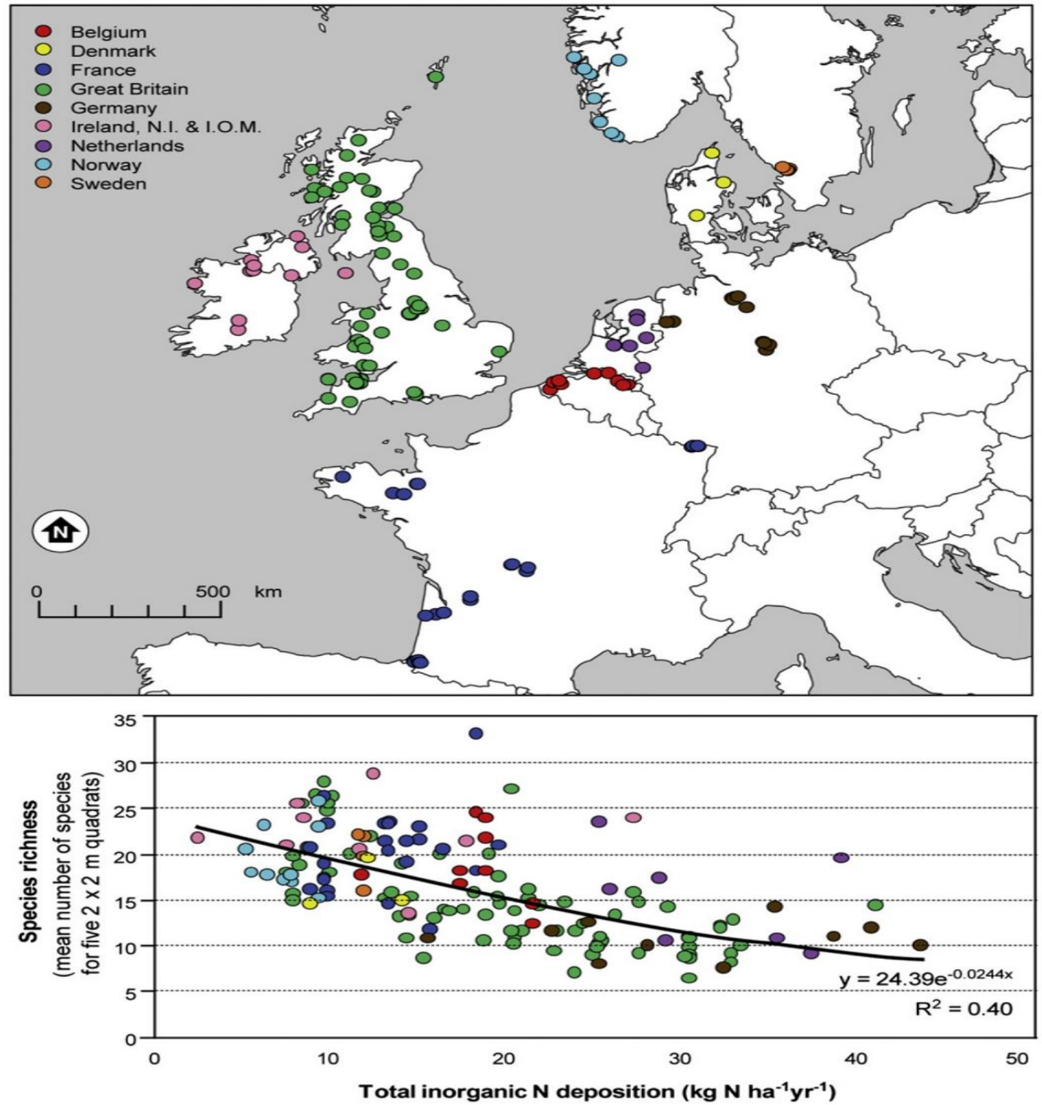
Community code	Community name
R1.2	Perennial calcareous grassland and basic steppes
R1.2	Mediterranean xeric grassland
R1.7	Closed non-Mediterranean dry acid and neutral grassland
R1.9	Open non-Mediterranean dry acid and neutral grassland, including inland dune grassland
R2.2	Low and medium altitude hay meadows
R2.3	Mountain hay meadows
R3.5	Moist or wet oligotrophic grassland
R4.2	Moss and lichen dominated mountain summits, ridges and exposed slopes
R4.3	Acid alpine and subalpine grassland
R4.4	Calcareous alpine and subalpine grassland

Closed non-Mediterranean dry acid and neutral grassland



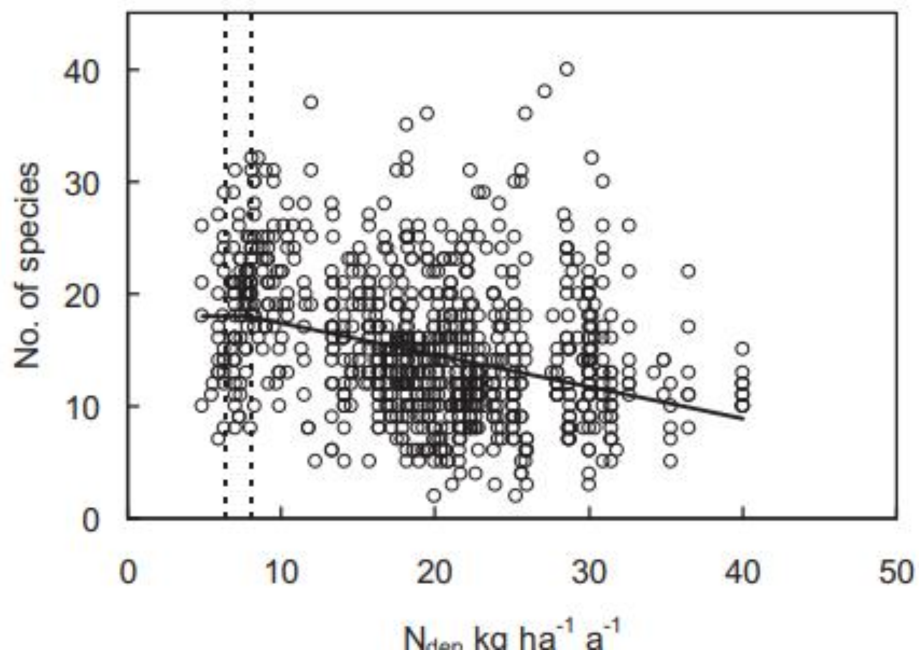
Proportion of graminoids following 3 years of adding 19 kg N ha-1 yr-1 in two non-Mediterranean dry acid closed grasslands in Southern Sweden (Berlin et al., 1998).

Gradient studies



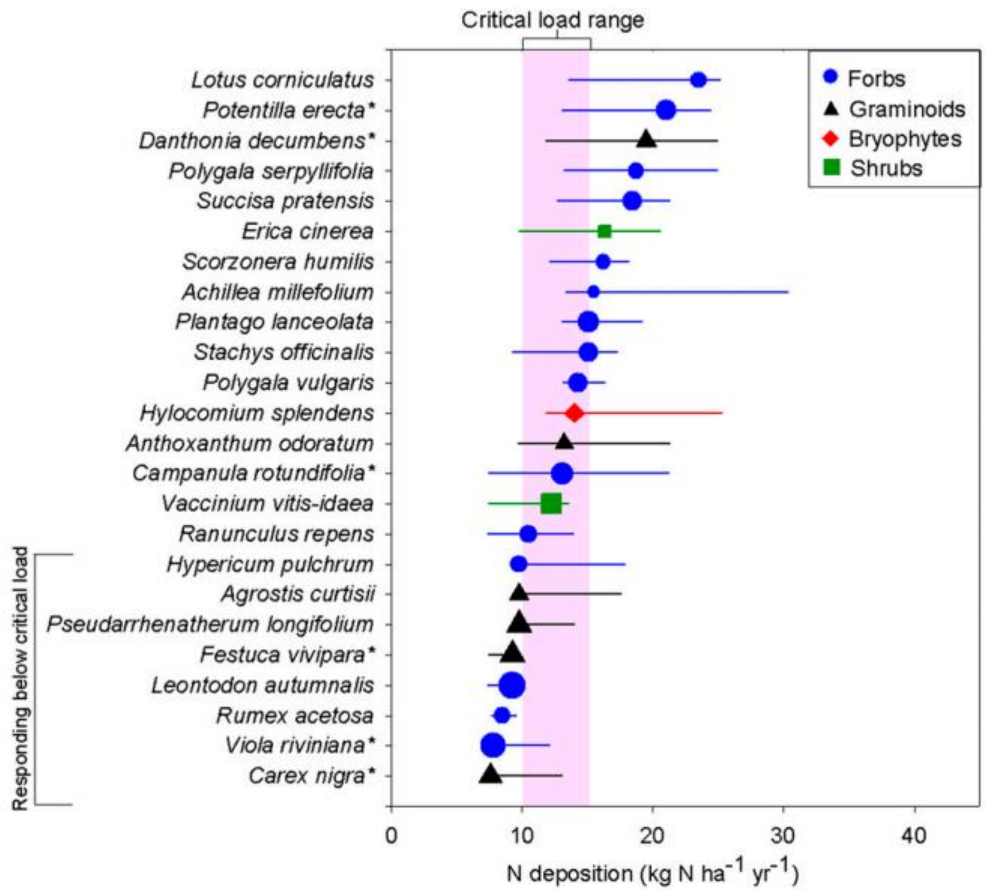
Stevens et al., 2010

Threshold analysis



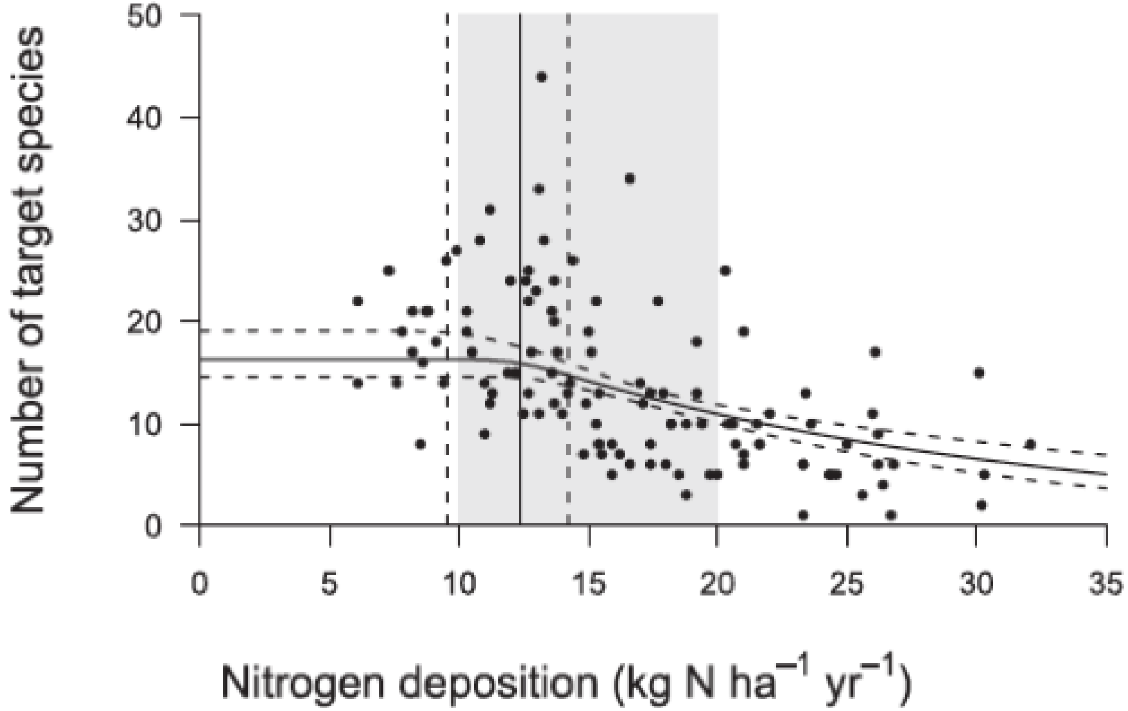
Tipping et al. 2013

TITAN



Payne et al. 2013

Mountain hay meadows



Roth et al., 2017

CHAPTER

Heathland, scrub and tundra (EUNIS class S)

Leon van den Berg,

Julian Aherne,
Andrea Britton,
Simon Caporn,
Héctor García Gómez
Liv Guri Velle

Chapter - Heathland, scrub and tundra

EUNIS class S (former code EUNIS class F)

2011 review CLempN (In bold are the changes with respect to the 2003 review)

Ecosystem type	EUNIS code	kg N ha^{-1} yr^{-1}	Reliability	Indication of exceedances
Tundra	F1	**3-5**[a]	#	Changes in biomass, physiological effects, changes in species composition in bryophyte layer, decrease in lichens
Arctic, alpine and subalpine scrub habitats	F2	**10-15**[a]	#	Decline in lichens, bryophytes and evergreen shrubs
Northern wet heath	F4.11			
• 'U' *Calluna*-dominated wet heath (upland moorland)	F4.11[a,b]	10-20	#	Decreased heather dominance, decline in lichens and mosses, increased N leaching
• 'L' *Erica tetralix*-dominated wet heath (lowland)	F4.11[a,b]	**10-20**	(#)	Transition from heather to grass dominance
Dry heaths	F4.2[a,b]	10-20	##	Transition from heather to grass dominance, decline in lichens, changes in plant biochemistry, increased sensitivity to abiotic stress
Maquis, arborescent matorral and thermo-Mediterranean brushes	F5	**20-30**	(#)	Change in plant species richness and community composition

New literature from 2010 to 2021

~140 papers found for class S published since 2010

- ~90% field studies
- ~7% gradient studies
- ~3% other

Decent number of papers in the sub-classes:

- S1 Tundra
- S2 Arctic, alpine and subalpine scrub habitats
- S4 Dry and wet temperate heath
- S5 Mediterranean scrub and maquis

Limited number of papers in habitats

- S3 Temperate and Mediterranean-montane scrub
- S6 Garrigue
- S7 Spiny Mediterranean heaths
- S8 Canary Island xerophytic scrub

Current status

- Reviewing papers
- Contacting lead authors when in doubt of EUNIS class or background deposition
- Summarising effects

CHAPTER

Woodland, forest and other wooded land (EUNIS class T)

Sabine Braun,

Rocio Alonso,
Frank Ashwood,
Tomas Chuman,
Lucienne de Witte,
Thomas Dirnböck,
Per Erik Karlsson,
Sirkku Manninen,
Michael Perring,
Hans Tömmervik,
Simon Tresch,
Liisa Ukomaaganho,
Elena Vanguelova,
Peter Waldner,
James Weldon

CHAPTER

Woodland, forest and other wooded land (EUNIS class T)

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Sirkku Manninen,
Michael Perring,
Hans Tömmervik,
Simon Tresch,
Liisa Ukomaaganho,
Elena Vanguelova,
Peter Waldner,
James Weldon

Version from 2011: 255 references

Current draft: 500 references

Inclusion of Epidemiological Studies

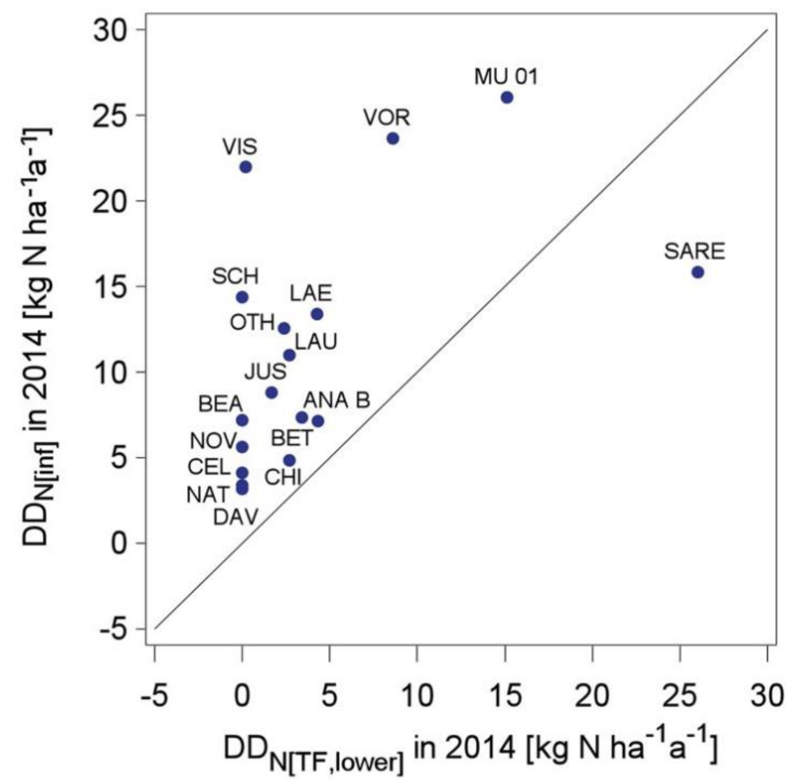
- Since 2011, research has focused mostly on epidemiological studies.
- Advantages are a broad range of ecological conditions and usually low concentrations and the possibility to include interactions.
- Important confounding variables must be included (e. g. drought) and appropriate statistical models applied.
- The epidemiological studies use various measures for N deposition.
- We need a definition of an effect level.

Measures of N Deposition: Throughfall deposition

Comparison between dry deposition DDN estimated with the inferential method (DDN[inf]) and the lower estimate of DDN based on throughfall measurements (DDN[TF,lower]).

Throughfall is measured on site but underestimates total N deposition

Dry deposition measured with inferential methods



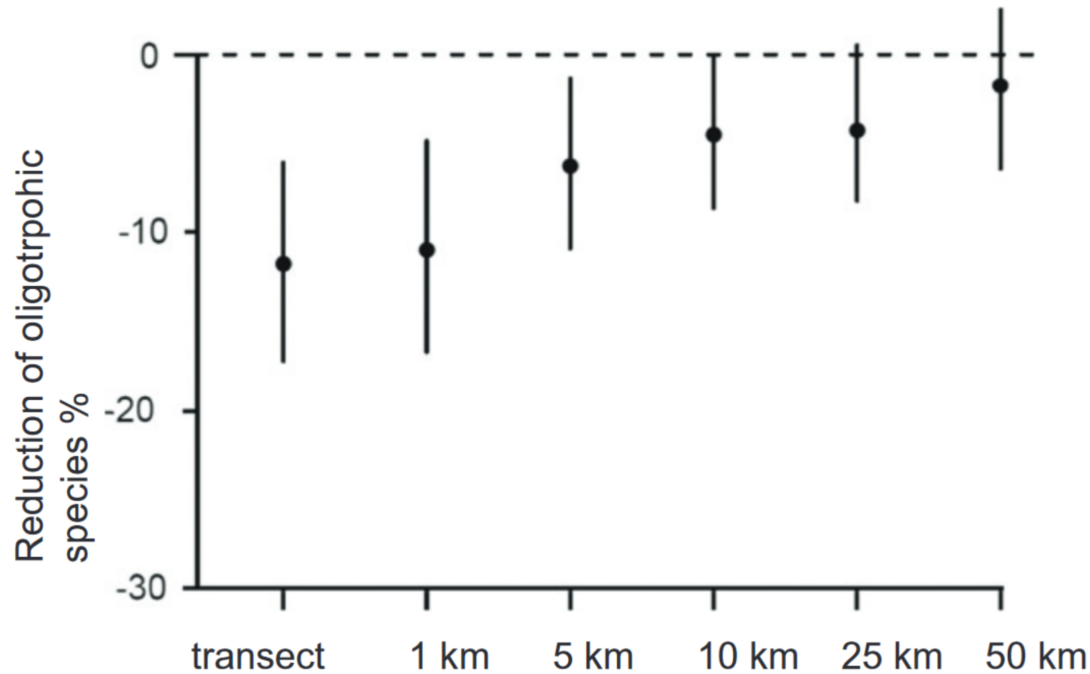
Throughfall

Thimonier, A., Kosonen, Z., Braun, S., Rihm, B., Schleppi, P., Schmitt, M. et al. (2019). *Atmospheric Environment*, *198*, 335–350

Measures of N Deposition: EMEP model

Percentage reduction and 95% confidence intervals of oligotrophic species number at a N deposition of 20 kg ha^{-1} yr^{-1} (Kohli et al., 2014; n=428 transects).

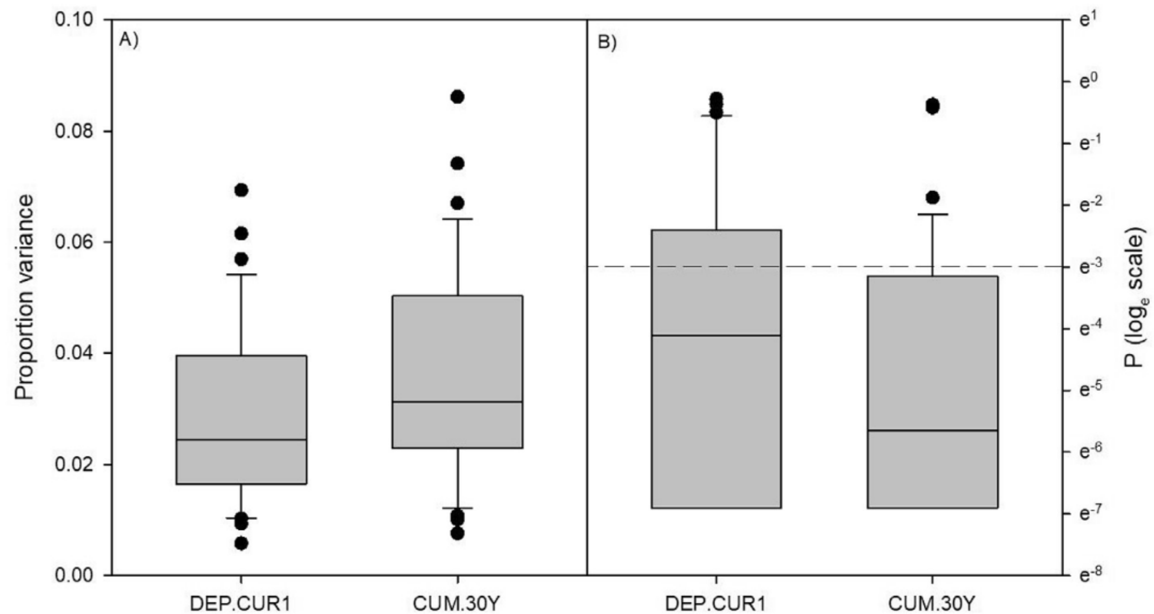
Too coarse grid size for deposition models leads to loss of precision



Braun, S., Achermann, B., De Marco, A., Pleijel, H., Karlsson, P. E., Rihm, B. et al. (**2017**). *Science of the Total Environment, 603–604.*

Measures of N Deposition: Short-term vs. long-term

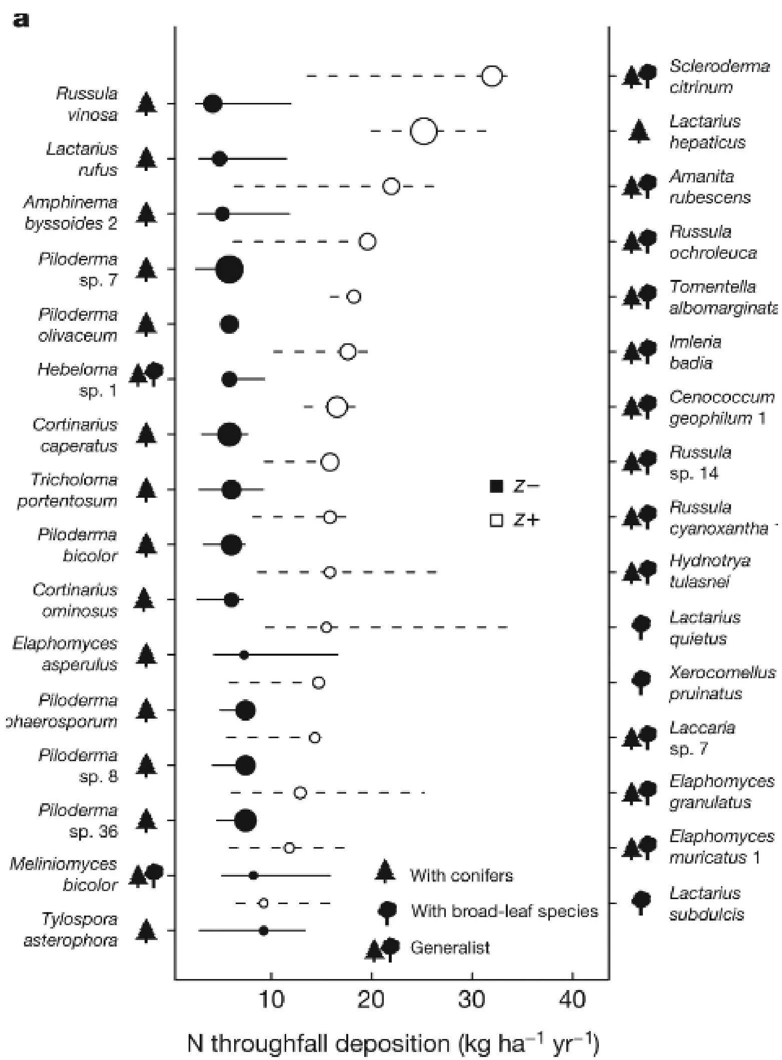
Comparison of single-year current deposition (DEP.CUR1) and 30 year cumulative deposition (CUM.30Y) for all vegetation datasets (without co-variates) in terms of explained variance (A) and P-value (B). Dashed horizontal line shows P=0.05.



Use long-term N exposure (cumulative or ev. long-term average)

Payne, R. J., Campbell, C., Britton, A. J., Mitchell, R. J., Pakeman, R. J., Jones, L. et al. (**2019**). *Environmental Pollution*, *247*, 319–331.

Mycorrhizal study in ICP Forest plots: Van der Linde 2018

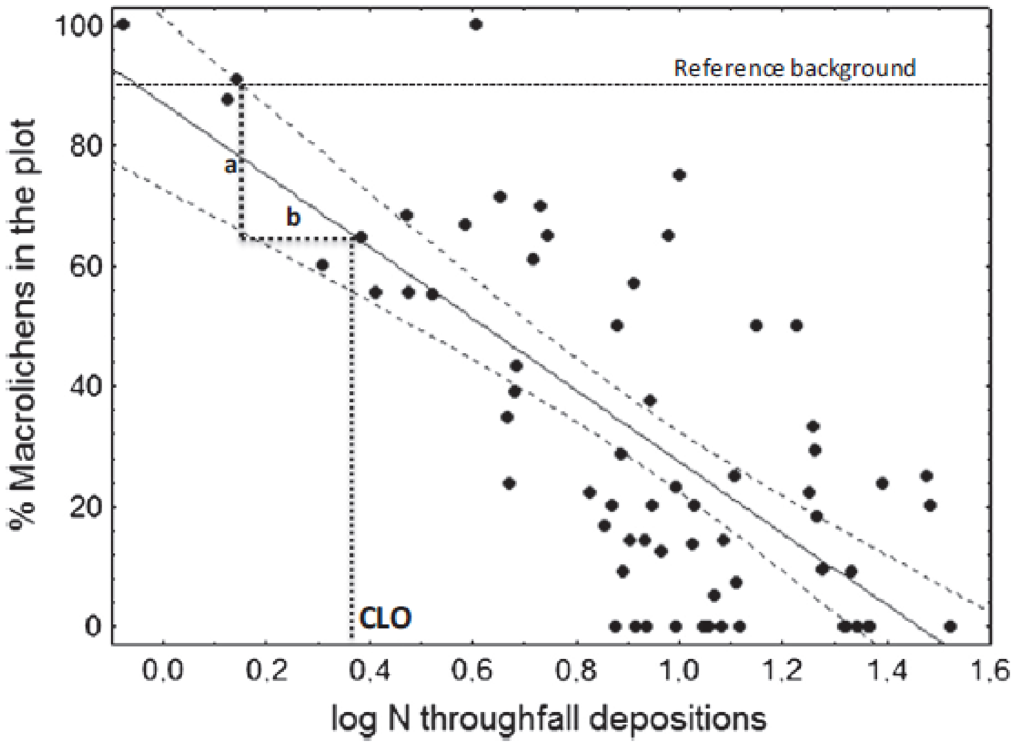


Ectomycorrhizal threshold indicator taxa analysis results. Black symbols show taxa declining with increasing N deposition (z–), open symbols depict increasing taxa (z+). Symbol size is proportional to magnitude of response (z-score). Horizontal lines represent 5th and 95th quantiles.

Proposed critical load for N at 5-6 kg N ha^{-1} yr^{-1} for conifer forest and 10-20 kg N ha^{-1} yr^{-1} for broad-leaf forest

van der Linde, S., Suz, L. M., Orme, C. D. L., Cox, F., Andreae, H., Asi, E. et al. (**2018**). *Nature*, *558*(7709), 243–248.

Effect on macrolichens in the ICP Forest plots
Proposed Critical Load 2.4 kg N ha^{-1} yr^{-1}

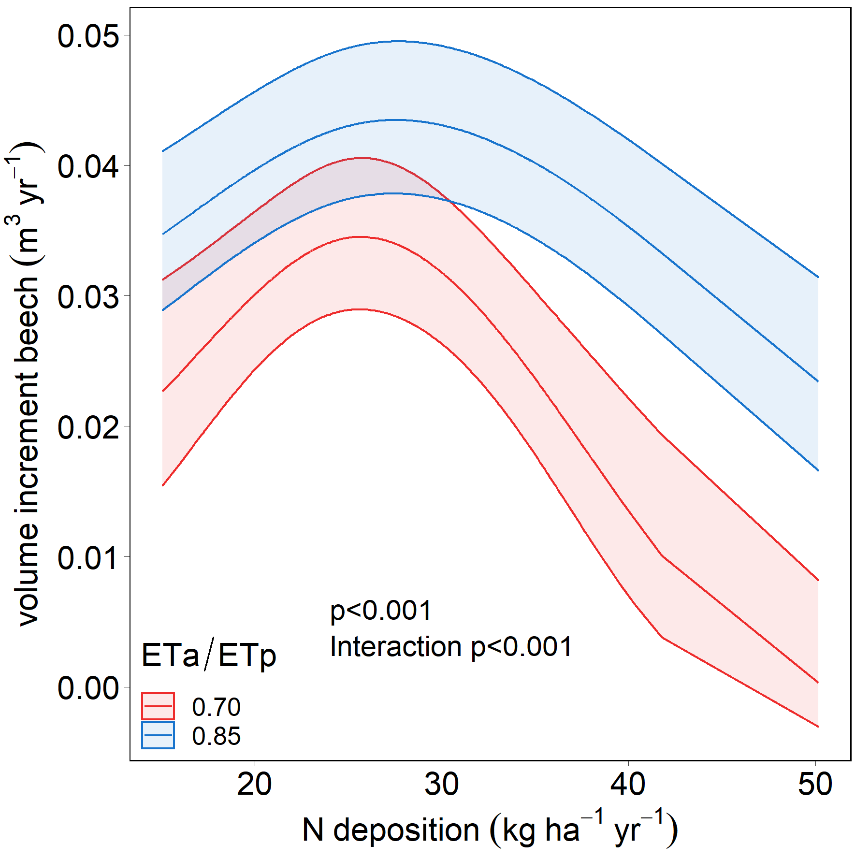


Plots with lowest depositions for which the response of % macrolichens was significantly different in the model was set as background reference (horizonetal dotted line). Their lower 95% confidence limit is calculated (line a) and the point corresponding where this is met on the regression line is found (line b).

Proposed critical load for macrolichens <3 kg N ha^{-1} yr^{-1}

Giordani, P., Calatayud, V., Stofer, S., Seidling, W., Granke, O. & Fischer, R. (**2014**). *Forest Ecology and Management*.

Interactions with drought

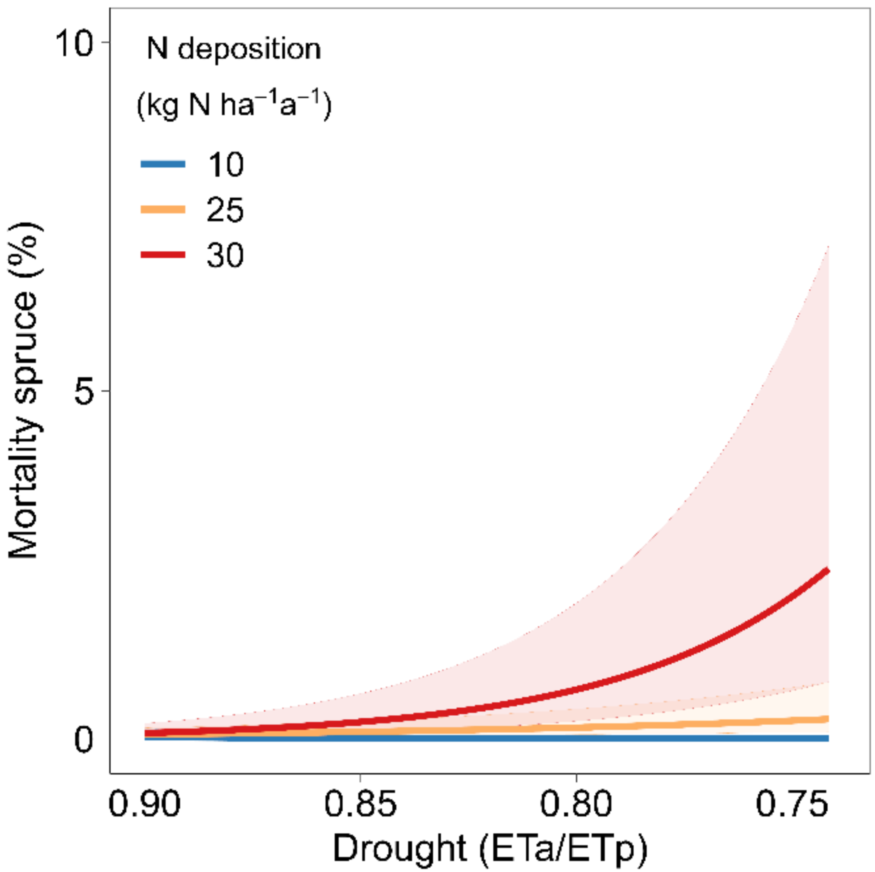


Basal area increment of Fagus sylvatica in relation to drought (seasonal average of the ratio between actual and potential evapotranspiration and grouped according to total N deposition (modelled, 1 ha resolution)

Drought may increase the sensitivity to nitrogen

Redrawn after:
Braun, Sabine, Schindler, C. & Rihm, B. (2017). Science of The Total Environment, 599–600, 637–646
7400 trees, 8 increment periods, 91 sites

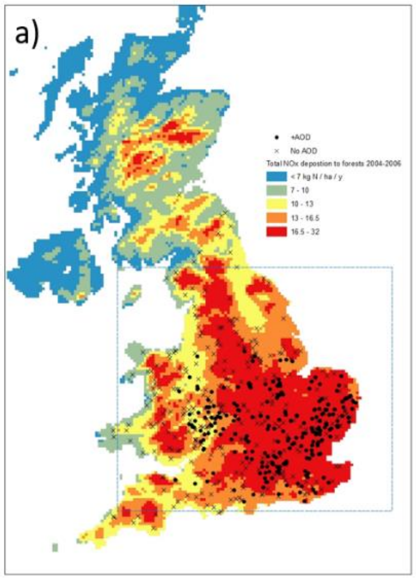
Interactions with drought and insects

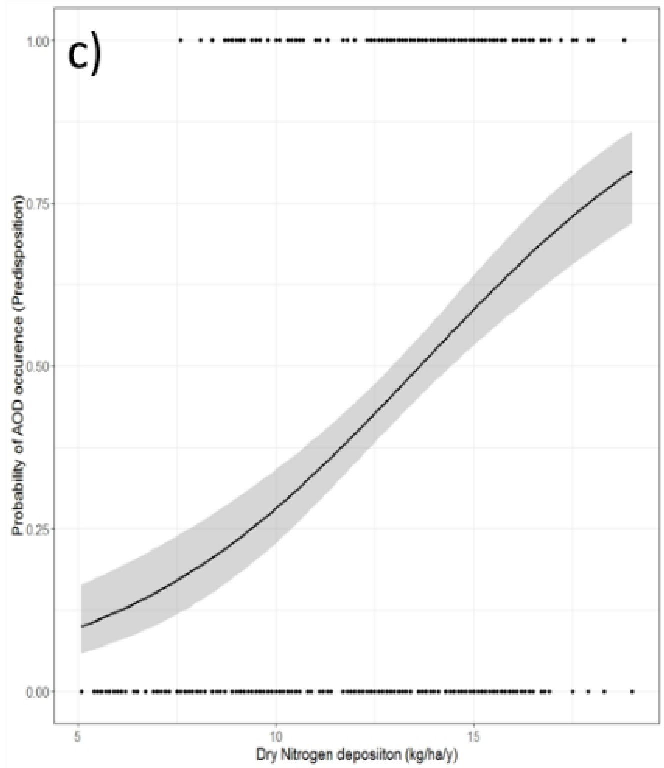


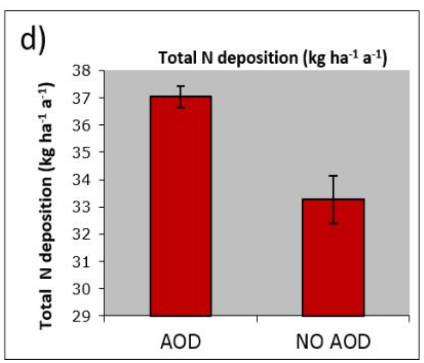
Mortalilty of Picea abies in Switzerland in relation to drought (quantified as ratio between actual and potential evapotranspiration averaged over tree previous seasons) with the interaction effect of N deposition. Number of dead trees: 1132, 76 sites, 131'819 tree observations during 36 years (Tresch et al. in prep.).

N deposition increased the sensitivity of Norway spruce to drought and bark beetle attacks

Interactions with pathogens





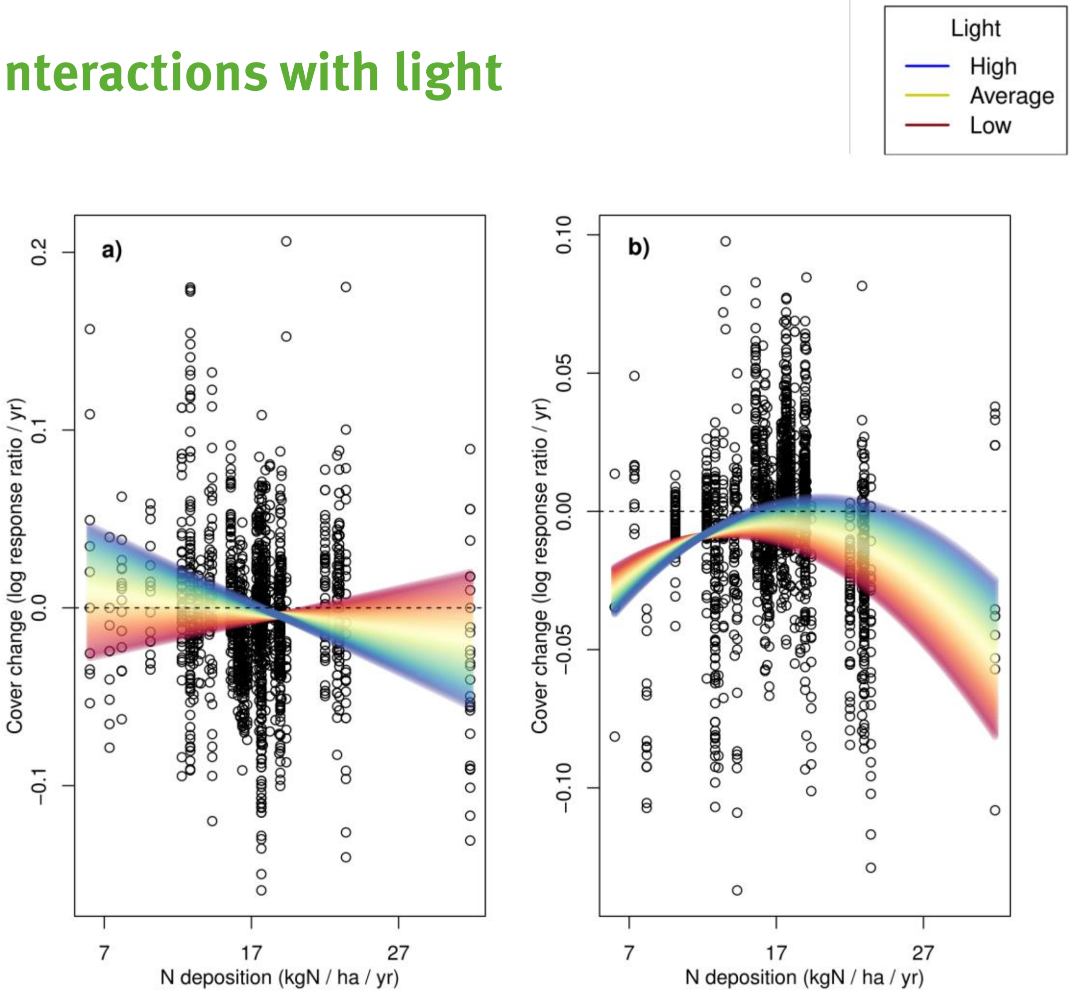


The Acute Oak Decline Syndrome in UK was correlated with dry N deposition

Brown, N., Vanguelova, E., Parnell, S., Broadmeadow, S. & Denman, S. (**2018**). *Forest Ecology and Management*, *407*, 145–154.

Results of a logistic regression model showing the increasing probability of Acute Oak Decline syndrome (AOD) occurrence as dry nitrogen deposition increases, the trend is shown with bold black line and the grey shaded area shows 95% confidence intervals ($p<0.001$, deviance=64.55, df=1) (c) and total N annual mean modelled total N)

Interactions with light



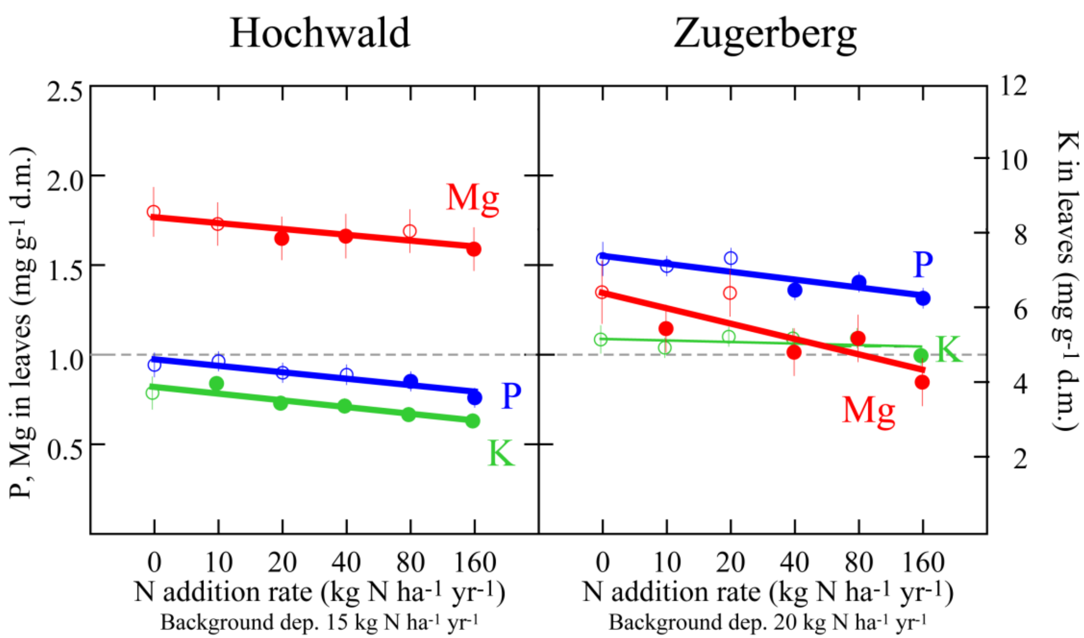
Plant community responses to N deposition between surveys across European deciduous temperate forests. (a) graminoid and (b) forb responses to N deposition based on the best fitting model using 1814 plots across 40 forest regions.

The response of light demanding species to N differed from the shade tolerant species

Perring, M. P., Diekmann, M., Midolo, G., Schellenberger Costa, D., Bernhardt-Römermann, M., Otto, J. C. J. et al. (2018). *Environmental Pollution*, *242*, 1787–1799.

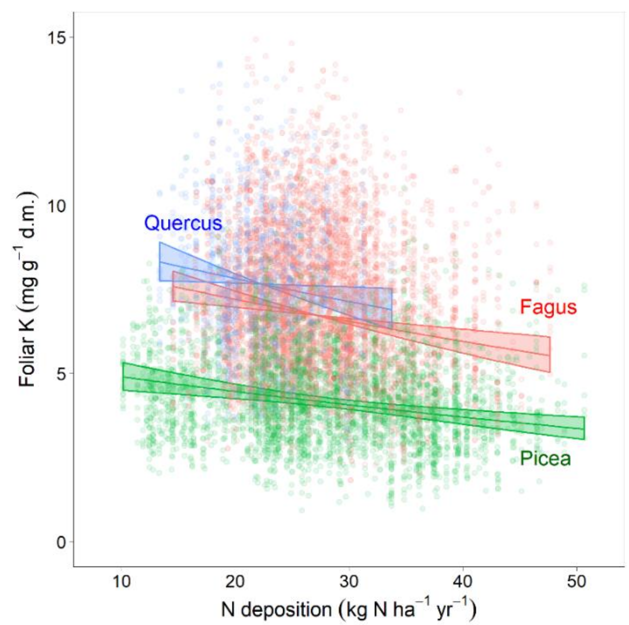
Comparison of experiment and gradient study N and foliar nutrient concentrations in *Fagus sylvatica*

Experimental N addition to young trees



Flückiger, W. & Braun, S. (2011).
http://www.bafu.admin.ch/wald/01198/01206/index.html?lang=de

Gradient study with mature trees



Braun, S., Schindler, C. & Rihm, B. (2020). *Frontiers in Forests and Global Change*, *3*(March), 1–15

Gradient studies may show more sensitive responses than experiments and thus lower critical loads

CHAPTER

Aspects of application

Markus Geupel,

Alice James Casas,
Christin Loran,
Reto Meier,
Anne-Katrin Prescher,
Isaura Rabago Juan-Aracil,
Thomas Scheuschner,
Kai Schwärzel

Overall objectives of the chapter

FRAMING: Scientific report authored by scientists

DISCUSSION OF APPLICABILITY OF THE SCIENTIFIC DATA

- Highlight existing forms of application (local, national and international level)

- Discuss weakness and strength of the data
  - In comparison to modeled CL data
  - For validation of CL models

- Illuminate further new forms of application
  - Inside the convention: assess air pollution risks for different ecosystems (including the covered biodiversity)
  - Outside the convention: Recommend application in "Nature conservation" assessments

RECOMMEND AND PROMOTE BROAD APPLICATION OF IMPORTANT SCIENTIFIC RESULTS !

Isaura: "increase visibility of WGE……"!

Structure, content, extent

EXTENT

Short, condensed chapter (up to max. 5 pages)

PROPOSED CONTENT

- Short introduction
- Limitations / advantages of the data including comparison to modelled data
- Examples for existing application in local, national or international policy
    - Including model validation
- Discuss applicability in other fields than air pollution i.e. nature conservation
- Discuss applicability in the convention to assess air pollution risks for different ecosystems (including the covered biodiversity)

Current state and next steps

CURRENT GROUP OF AUTHORS AND CO-AUTHORS

Markus Geupel, Christin Loran, Thomas Scheuschner, Reto Meier, Anne-Katrin Prescher, Alice James, Isaura Rabago

→ Please approach markus.Geupel@uba.de, christin.loran@uba.de if you are interested to contribute

WHAT HAS HAPPENED IN THE GROUP

- Discussed the contents and extent of such a chapter in the above mentioned group
- Discussed, if the content of the chapter is needed within the report or if it was better to have this discussion in a accompanying recommendation of ICP M&M outside the report

→ We reinforced our decision to have the important information of this chapter included within this report

NEXT STEPS

- Collection and compilation of national contribution → **14 May 2021**
- Finalization of draft chapter → **mid June 2021**
- Internal review with experts and authors involved in other chapters
- Final Workshop → **October 2021**

Request to NFC

THANKS TO

AT, BE (FLANDERS), CA, CH, IE, NO AND UK

Which submitted information on the application of Clemp

We would propose to use this information in the chapter – referencing the country reports

PROVIDE SHORT INFORMATION ON APPLICATION IF AVAILABLE

- 250 words
- **14 May 2021 → cce@uba.de "Empirical CL national application"**
- Examples for national application can be, e.g.
  - Risk assessments
  - Legal procedures
  - Scientific recommendation (e.g. on website, in reports)
  - Model validation
  - Which policy arenas? Air quality, Nature conservation, Other?

Für Mensch & Umwelt

Umwelt Bundesamt

37TH TASK FORCE MEETING, 28TH CCE WORKSHOP & 2ND CDM MEETING

Thank you
to all the authors
for your contribution!