ENVIRONMENT AGENCY AUSTRIA umweltbundesamt



CLRTAP-WGE activities on air pollution impacts in Austria

Long-term effects of N and S deposition on ecosystems and biodiversity

Thomas Dirnböck

ENVIRONMENT AGENCY AUSTRIA umweltbundesamt

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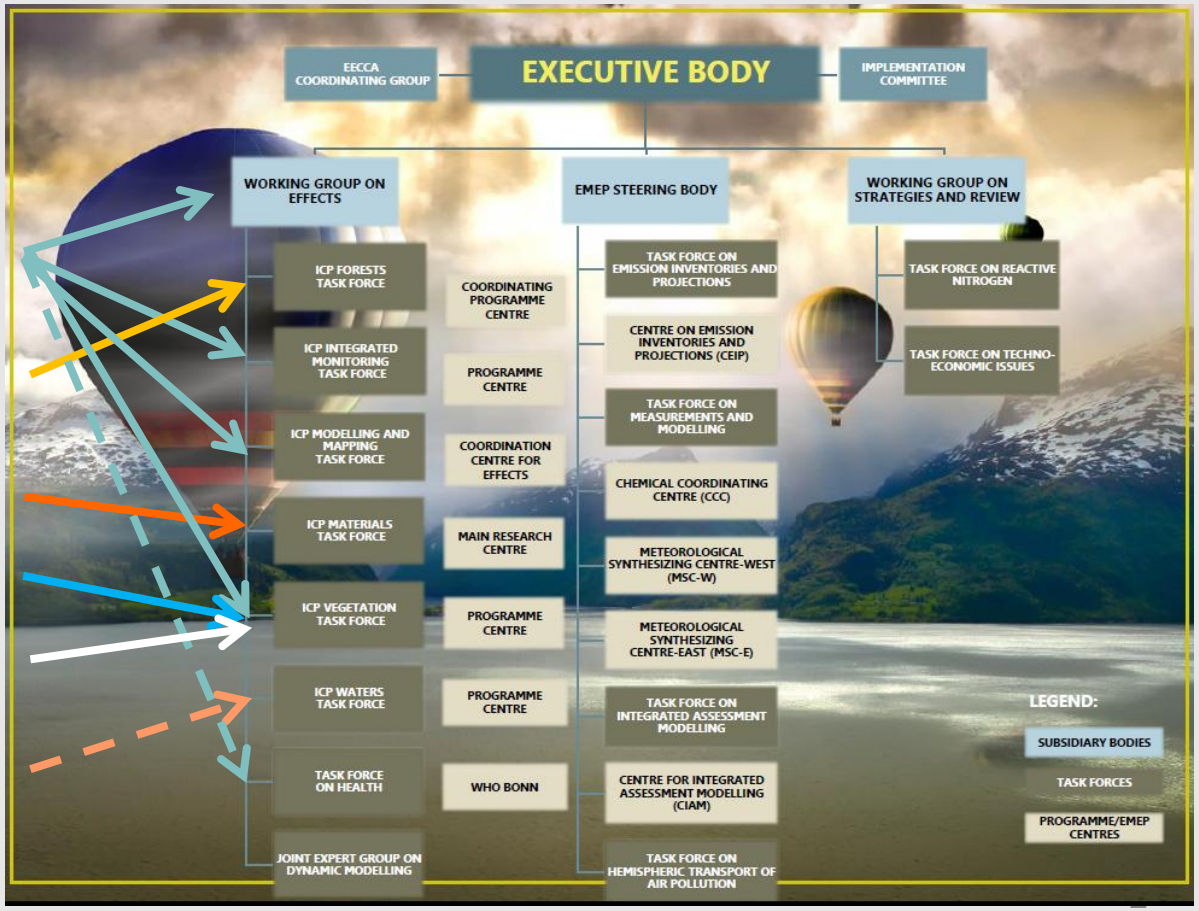
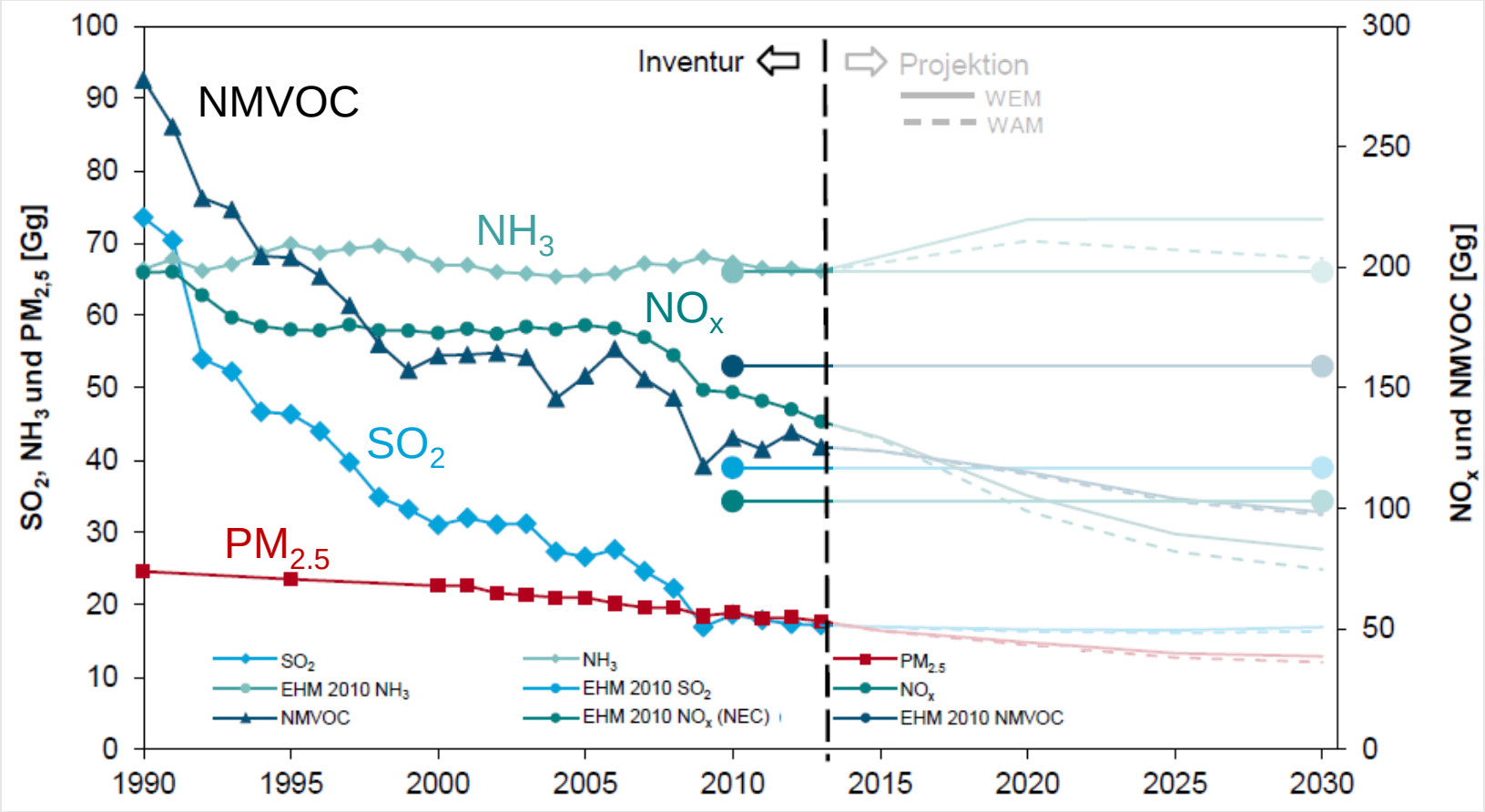
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY TOMORROW TODAY

University of Innsbruck

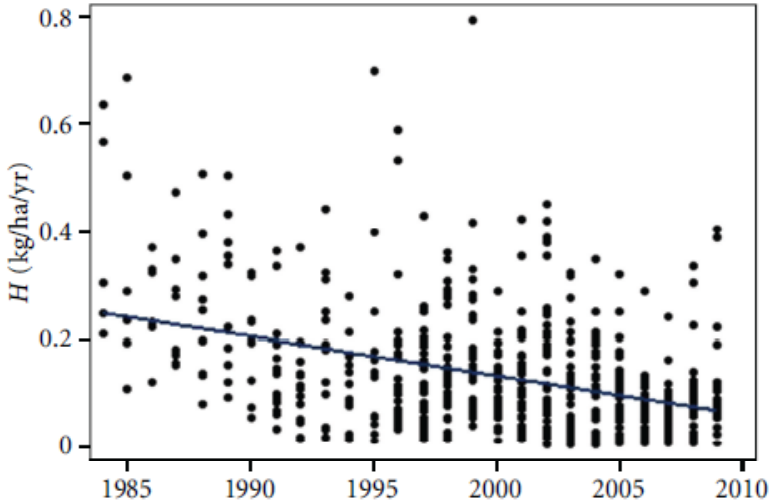


Emissions follow the European trend

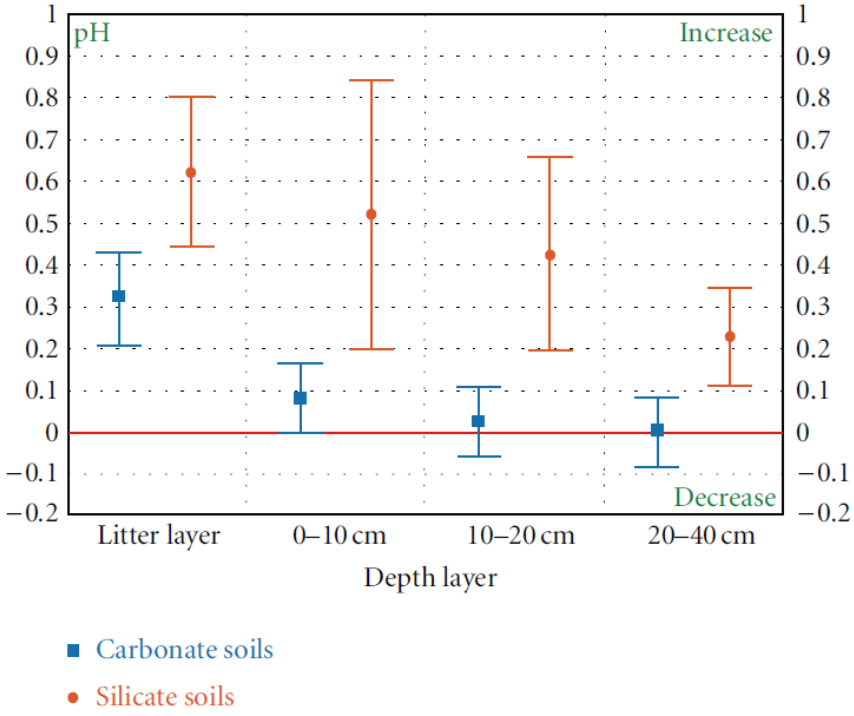


Less acid deposition increased forest soil pH

Acid deposition reduction in forest sites across Austria



pH increase in Austrian forest soils between 1987 and 2007

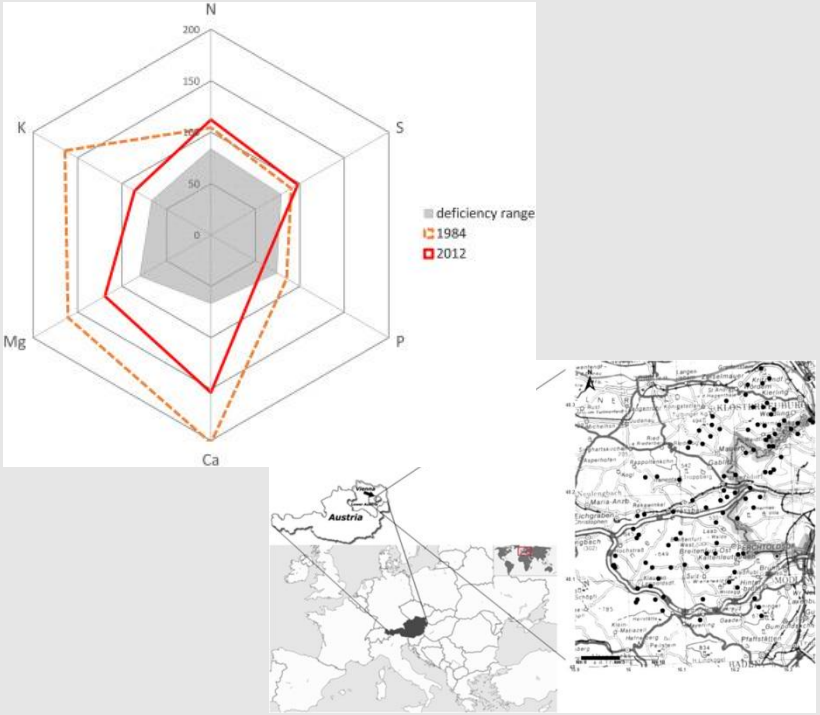


CL_{acid} exceedance < 1% of forest area

Jandl, R., S. Smidt, et al. (2012). "Acidification and Nitrogen Eutrophication of Austrian Forest Soils." Applied and Environmental Soil Science **2012**:

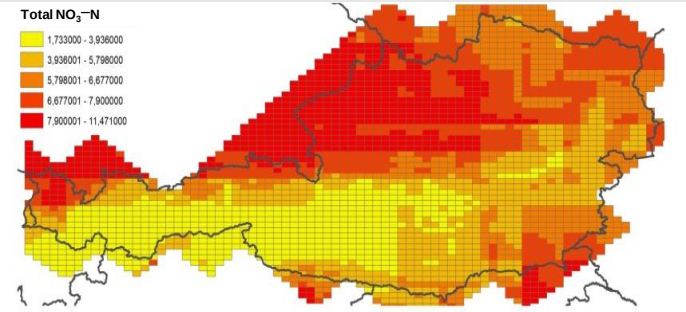
Recovery in soil acidity did not improve tree nutrition

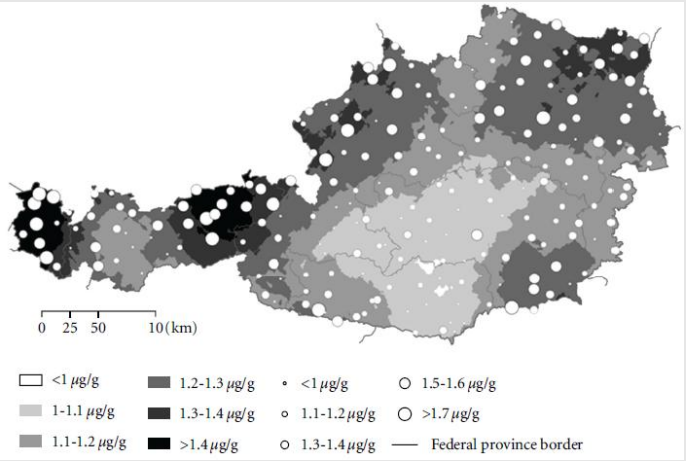
- Soil **pH increased but only in the topsoil**
- **No signs of recovery in deeper soil horizons**
- **Nutrient imbalances even worsened** since 1984 corroborating European trends

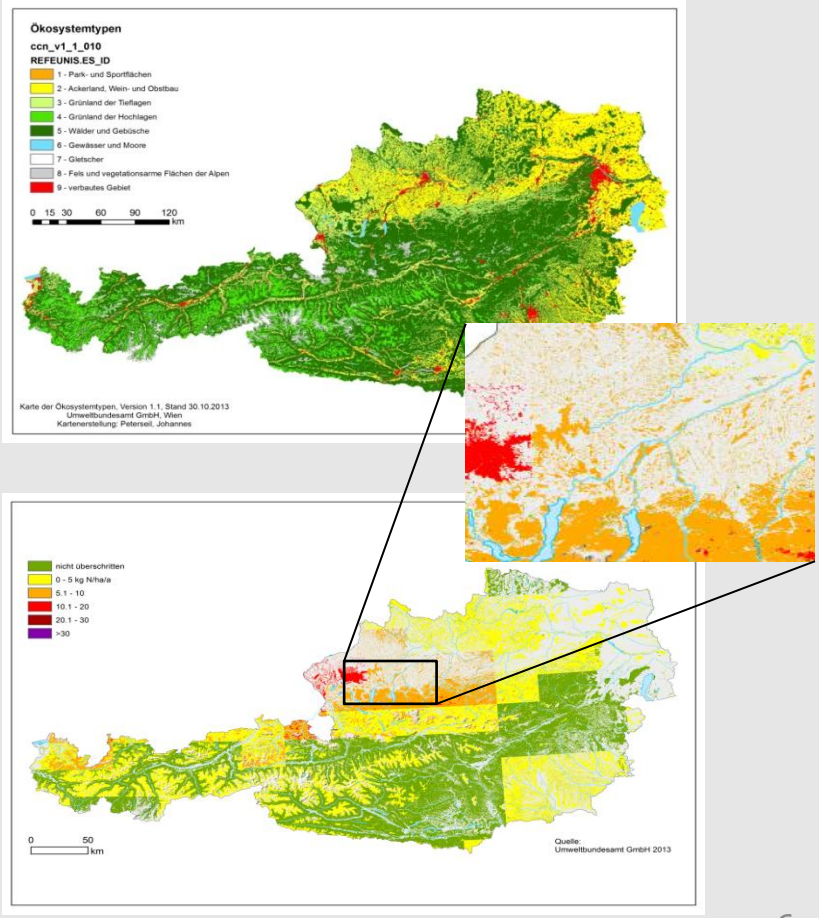


Berger et al. 2016. Env. Poll. http://dx.doi.org/10.1016/j.envpol.2016.06.024.

Nitrogen Critical Load Exceedance







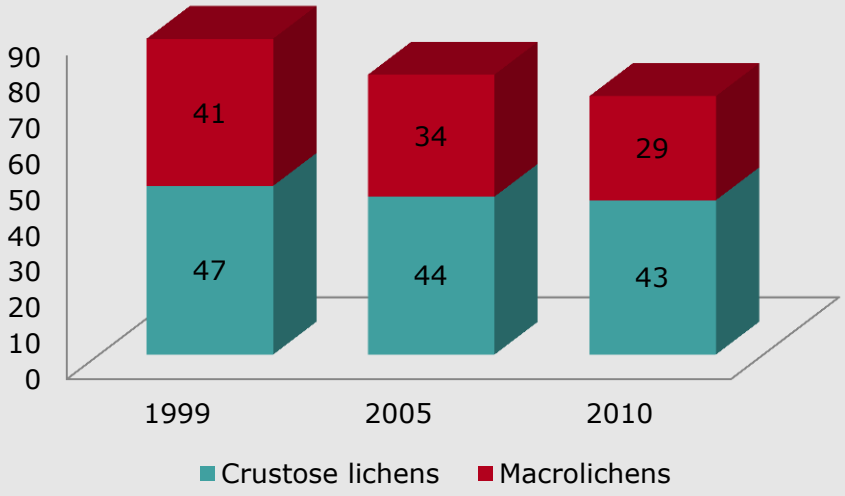
More than 50% of sensitive habitats will still experience exeedance of the Cl_{emp} by 2020

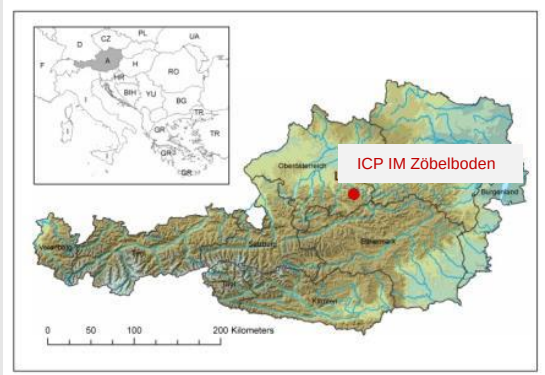
Flächenanteile von Stickstoff CL Überschreitungen in Österreich und in den Natura 2000 Gebieten. AAE beschreibt den Anteil der Fläche sensibler Habitate für die Überschreitungen auftreten. [1] siehe Tabelle 1 im Zwischenbericht; [2] AAE Berechnungen in 1 km Auflösung.

Sensible Habitate[1]	Fläche [km²]	Flächenanteil [%]	AAE_{2005} > 0 [%]	AAE_{2010} > 0 [%]	AAE_{2020} > 0 [%]
Gesamt Österreich	49.430	59	95	**66**	**47**
Natura 2000	10.545	83	98	**73**	**54**

Nitrogen eradicates lichen diversity

- **Drastic species loss** (17 species in ~10 years
- Eutrophication through **long-term N deposition** (ammonia in precipitation and in fog) was the main driver

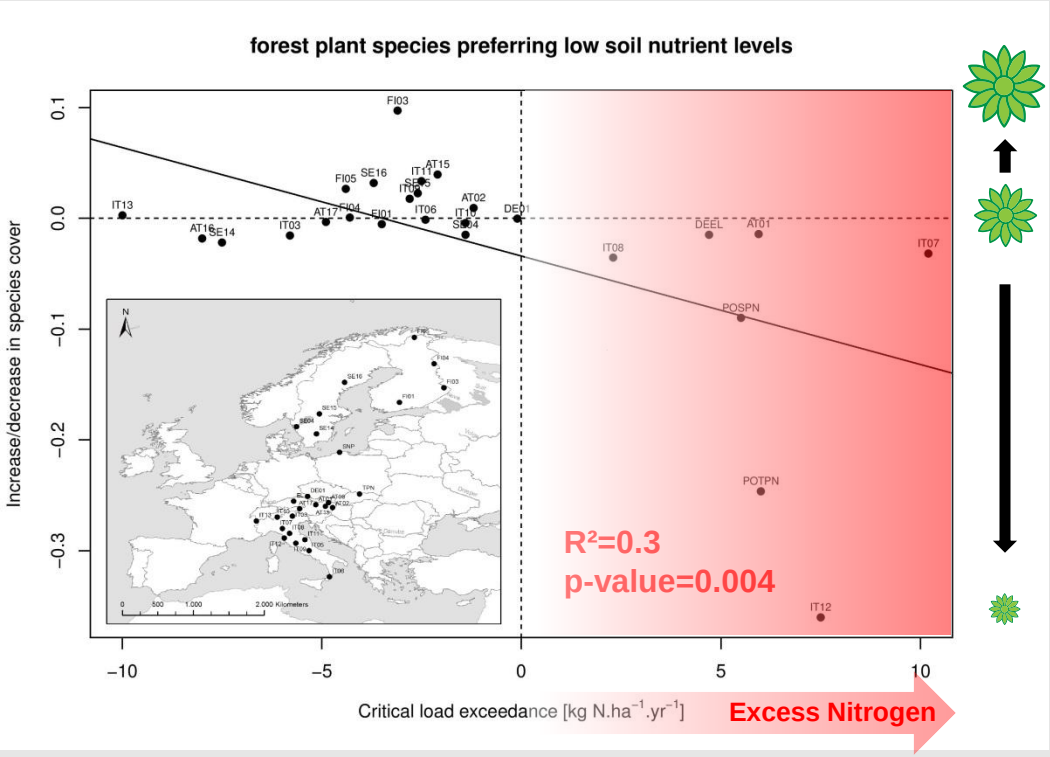




The cyanolichen *Pannaria conoplea, almost extinct at Zöbelboden* (Foto: Türk R.)

Mayer, M., Pfefferkorn-Dellali, V., Türk, R., Dullinger, S., Mirtl, M., Dirnböck, T. 2013. Significant decrease of epiphytic lichen diversity in a remote area in the European Alps, Austria. **Basic and Applied Ecology** 14: 396-403

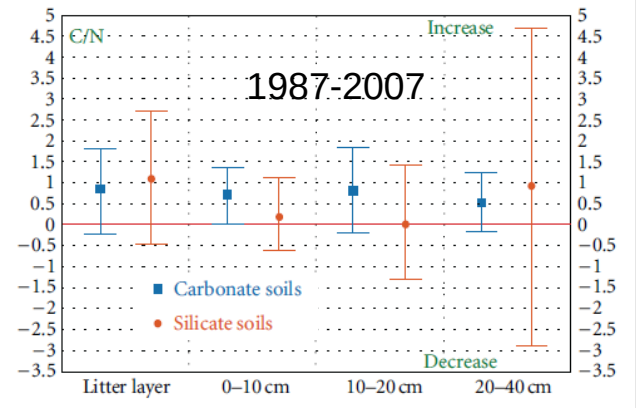
Where the Critical Load was exceeded the cover of oligotrophic species decreased

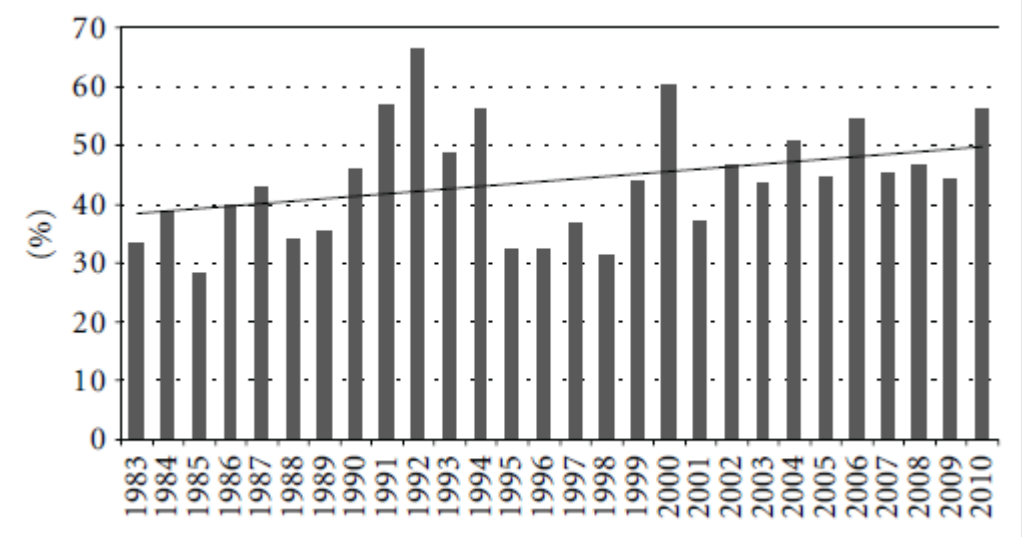


Dirnböck et al. Global Change Biology (2014)

Soils and trees are increasingly N deficient

- **Decreasing N availability** in forest soils
- Increase in the number of plots showing **N deficiency** in needles

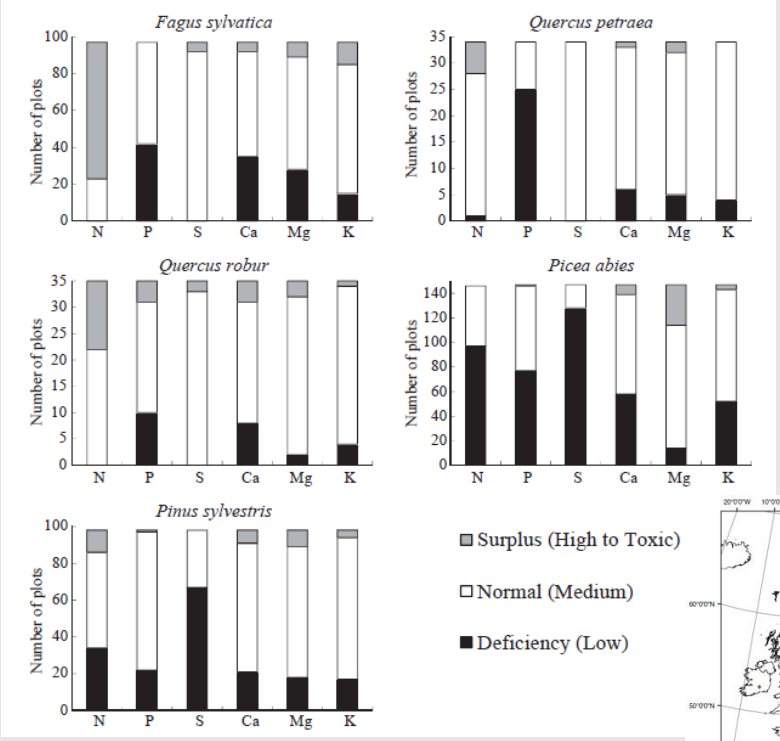


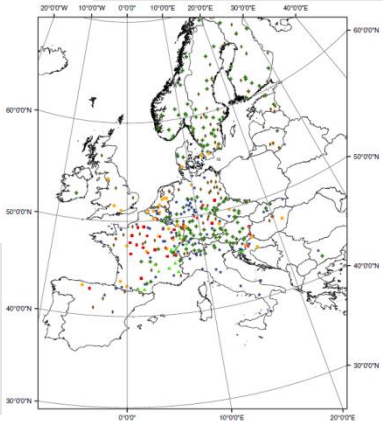


Jandl, R., S. Smidt, et al. (2012). "Acidification and Nitrogen Eutrophication of Austrian Forest Soils." Applied and Environmental Soil Science **2012**:

Large scale deterioration in tree nutrition

- P in particular is becoming limited
- **Higher tree nutrient demand due to higher growth rates** as an effect of N deposition (climate, CO_2)





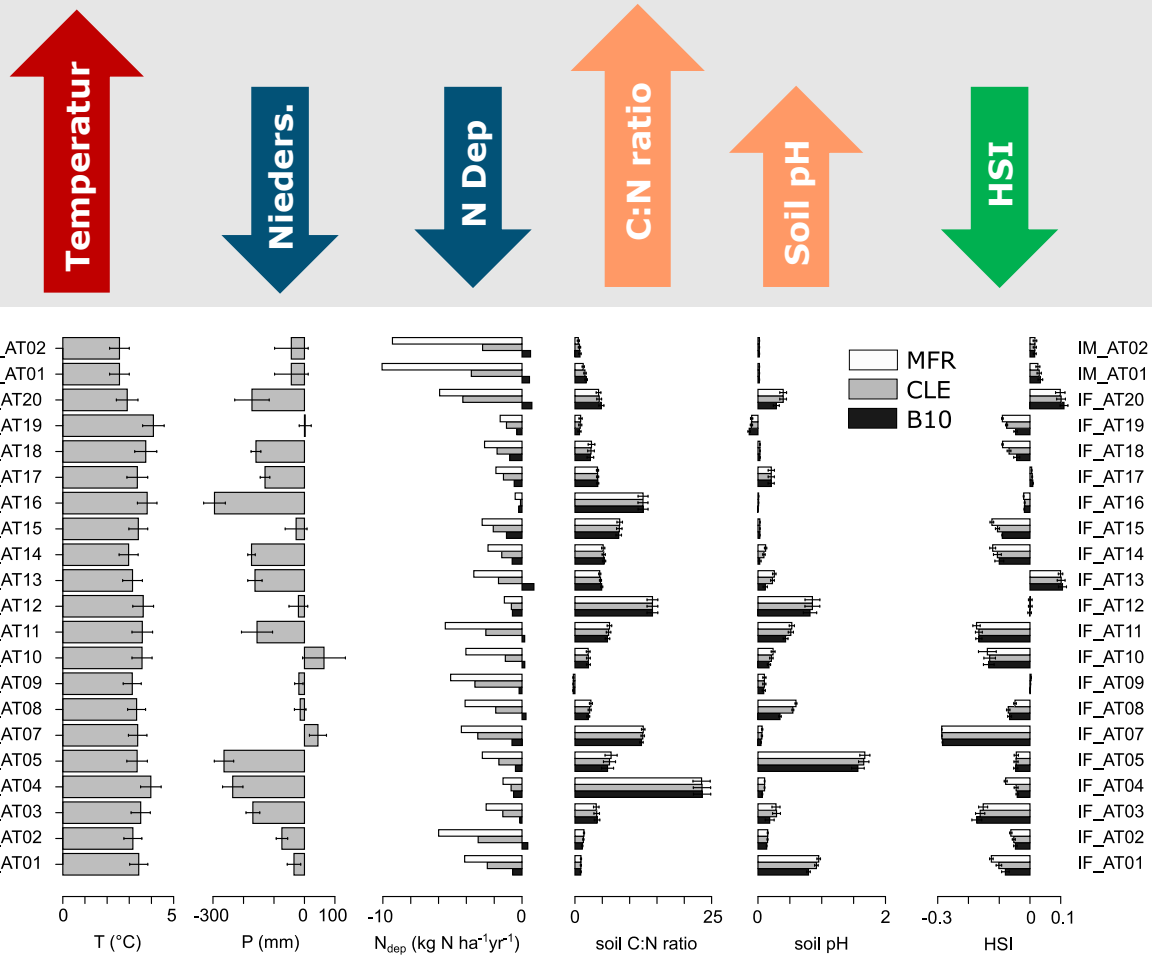
Jonard, M., A. Fürst, et al. (2015). "Tree mineral nutrition is deteriorating in Europe." Global Change Biology 21(1): 418-430.

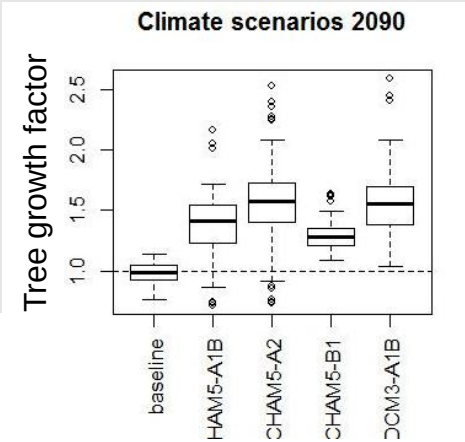
We wanted to know ….

…to which extent increasing tree growth is lowering N availabilty and therefore **reducing the risk of eutrophication** through N deposition?

- **Enhanced N uptake** by trees during climate warming **offsets N deposition effects**
- **Dry sites might be an exception**
- Overall **habitat suitability worsens** due to direct climate effects

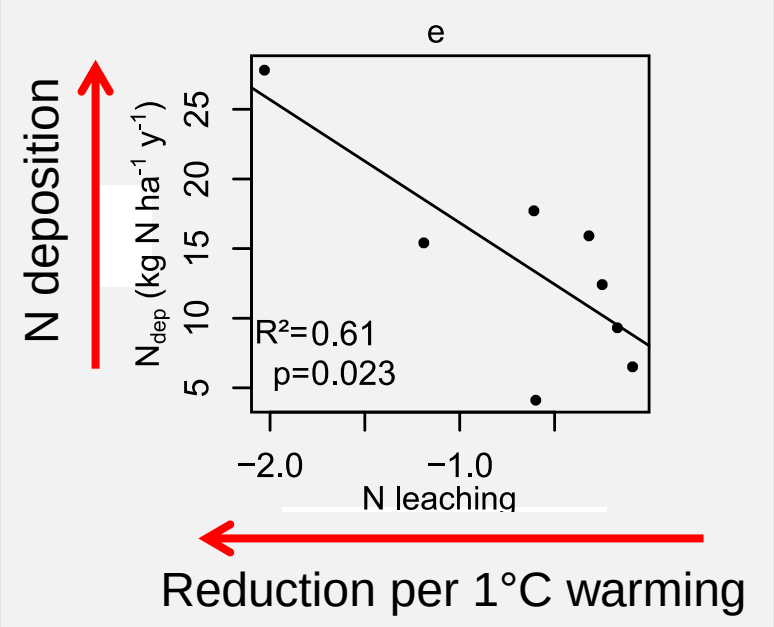
2100 senarios, 21 forest sites, VSD+/PROPS model



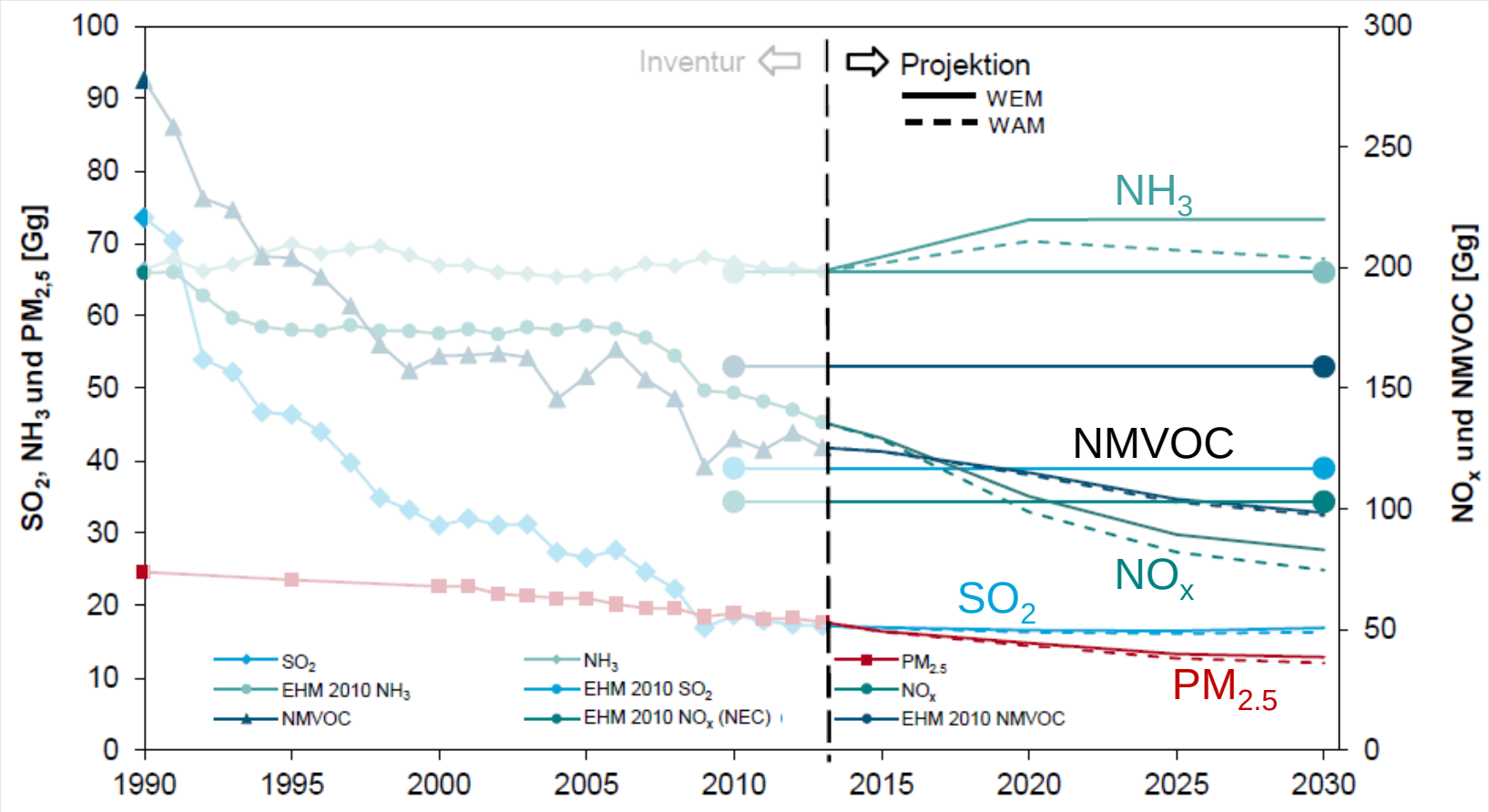


Climate change mitigates N saturation most where N deposition is/was high

- 8 ICP Forests and ICP IM sites
- LandscapeDNDC coupled C-N modelling
- 4 GCM scenarios until 2100
- CLE, MFR, B10 N deposition scenarios



Outlook to future emission scenarios



Conclusions

- **Recovery from acidification is very slow** in forests
- **Forest growth increase** during the last decades **might have mitigated stronger N effects**
- **Climate change can offset N deposition effects** in future in Austrian forest ecosystems
  - Drier forest areas with high N deposition remain at risk
  - Very complex and still uncertain – **monitoring and further research**
- More knowledge needed about **N deposition effects in semi-natural/natural grassland**
- **Ammonia remains an issue**

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