CLRTAP-WGE activities on air pollution impacts in Austria
Long-term effects of N and S deposition on ecosystems and biodiversity

Thomas Dirnböck
CLRTAP-WGE activities in Austria
Emissions follow the European trend

- SO$_2$
- NH$_3$
- NO$_x$
- PM$_{2.5}$
- NMVOC
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

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

Nitrogen Critical Load Exceedance
More than 50% of sensitive habitats will still experience exceedance of the Cl\textsubscript{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.

<table>
<thead>
<tr>
<th>Sensible Habitat¹</th>
<th>Fläche [km(^2)]</th>
<th>Flächenanteil [%]</th>
<th>AAE\textsubscript{2005} &gt; 0 [%]</th>
<th>AAE\textsubscript{2010} &gt; 0 [%]</th>
<th>AAE\textsubscript{2020} &gt; 0 [%]</th>
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<tr>
<td>Gesamt Österreich</td>
<td>49.430</td>
<td>59</td>
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<tr>
<td>Natura 2000</td>
<td>10.545</td>
<td>83</td>
<td>98</td>
<td>73</td>
<td>54</td>
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</table>
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

![Crustose lichens and Macrolichens bar chart]

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

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

$R^2 = 0.3$
$p$-value $= 0.004$

Soils and trees are increasingly N deficient

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

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$_2$)

We wanted to know ....

...to which extent increasing tree growth is lowering N availability 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

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**Climate scenarios 2090**

<table>
<thead>
<tr>
<th>Tree growth factor</th>
<th>Baseline</th>
<th>HADIS-A1B</th>
<th>CHAOS-A2</th>
<th>CHAOS-B1</th>
<th>CMIP3-A1B</th>
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</tbody>
</table>

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**2100 scenarios, 21 forest sites, VSD+/PROPS model**

**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
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

![Graph showing the relationship between N deposition and N leaching with a regression line and R² value of 0.61, p-value of 0.023.]
Outlook to future emission scenarios

- SO$_2$
- NH$_3$
- NMVOC
- NO$_x$
- PM$_{2.5}$
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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