ICP FORESTS
BRIEF #2
2018

LRTAP
Long-range Transboundary Air Pollution

ICP Forests

Status and trends of inorganic nitrogen deposition to forests in Europe

KEY MESSAGES

1

Although nitrogen is essential for plant growth, excessive nitrogen deposition can lead to adverse effects on forest ecosystems

2

Measurements show that deposition of inorganic nitrogen is highest in Central Europe

3

Between 2000 and 2015, throughfall deposition decreased by ~24% on highly polluted forest sites and ~16% on less polluted sites. Overall, the decrease has been greater for nitrate (26%) than ammonium (18%)

4

Despite the decrease in inorganic nitrogen deposition a substantial proportion of ICP Forests sites are still at risk of eutrophication

THÜNEN

wge Working Group on Effects of the Convention on Long-range Transboundary Air Pollution

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Excess deposition of nitrogen results in a range of adverse effects in forests and other ecosystems. In 2010, about 60% of the EU terrestrial ecosystem area received more nitrogen than acceptable in order to preclude harmful effects. This ICP Forests Brief informs about the development of inorganic nitrogen deposition, i.e. nitrate (NO_3^-) and ammonium (NH_4^+), in precipitation under the forest canopy (throughfall) at intensive forest monitoring sites in Europe between 2000 and 2015.

Why is nitrogen deposition to forest ecosystems a key issue?

Anthropogenic emissions have resulted in high rates of nitrogen deposition to forests for decades. Although nitrogen is an essential nutrient for plants and may stimulate tree growth, especially in areas with naturally low soil nitrogen availability, prolonged periods of high nitrogen deposition can have harmful effects on forest ecosystems. These include:

- Changes in soil chemistry including eutrophication, acidification, and increased nutrient losses in seepage water, risking the pollution of groundwater resources.
- Adverse effects on tree health by inducing nutrient imbalances and increasing sensitivity to insect damage, frost, and storms.
- Changes in biodiversity at the forest floor – with long-standing species of ground vegetation, lichens, and fungi declining or becoming locally extinct, accompanied by an increase in species more adapted to high nitrogen availability.


Tanja Sanders

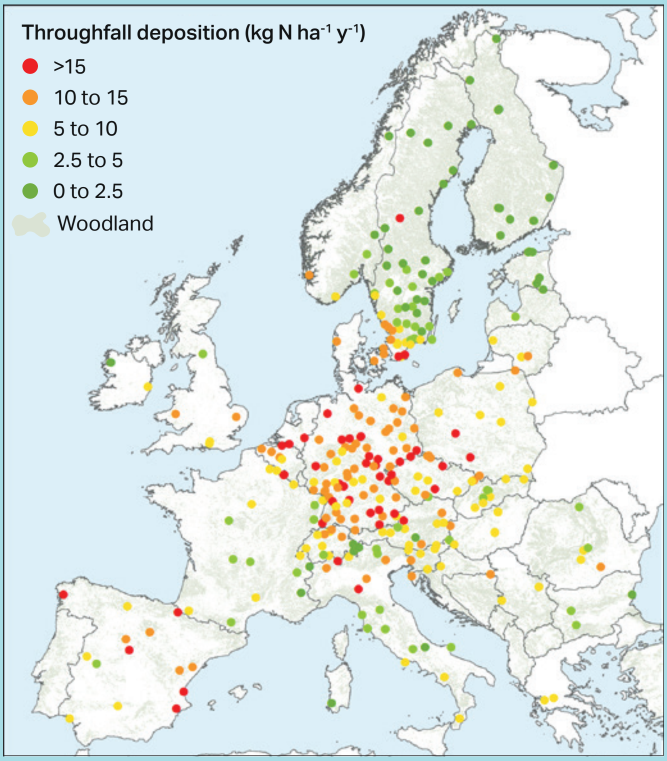
Inorganic nitrogen deposition to forest ecosystems

1 Current status

For ICP Forests sites in areas with comparatively high rates of nitrogen deposition, primarily Central Europe, current levels of inorganic nitrogen in throughfall are around 10–20 kg N ha^{-1} y^{-1}. In other areas, for example northern Scandinavia, throughfall deposition is often below 5 kg N ha^{-1} y^{-1}.

Throughfall deposition at individual sites ranges from 0.3 to 29 kg N ha^{-1} y^{-1}, with a median of 9 kg N ha^{-1} y^{-1}. On average, the contribution from ammonium and nitrate is roughly equal.

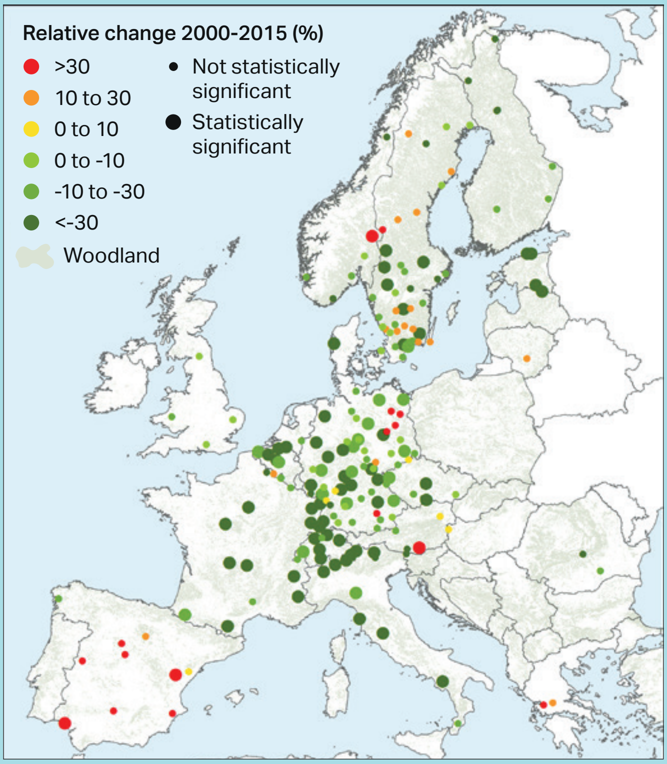
The thresholds for total nitrogen deposition to forest ecosystems below which adverse effects are not expected – the 'critical load' – are 10–20 kg N ha^{-1} y^{-1} for deciduous forests and 5–15 kg N ha^{-1} y^{-1} for coniferous forests. Measurements show that these thresholds are currently exceeded at many forest sites in Europe.



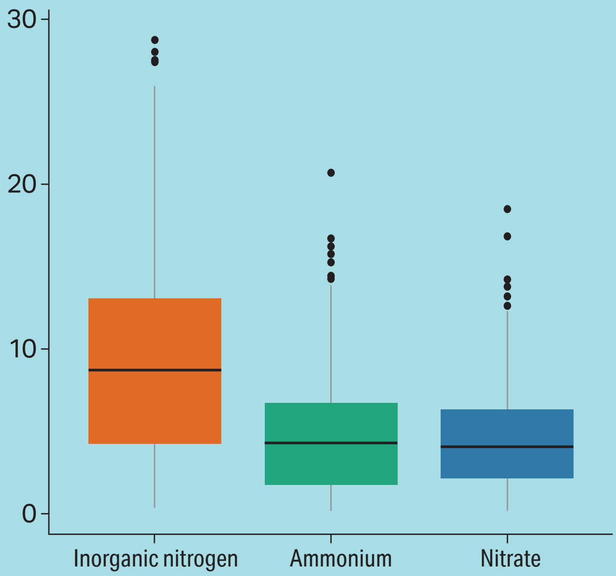
2 Recent trends

Although deposition rates of inorganic nitrogen in throughfall are currently high at many ICP Forests sites, measurements show a clear decrease at most sites between 2000 and 2015, especially at the highly polluted sites. The third of sites with the highest initial (2000–2004) rate of throughfall deposition show a median reduction of 24% between 2000 and 2015, whereas the third of sites with the lowest initial (2000–2004) rate of throughfall deposition show a corresponding reduction of 16%.

On many sites, throughfall deposition of nitrate decreased faster than for ammonium. Overall, nitrate deposition decreased by 26% and ammonium by 18% between 2000 and 2015.

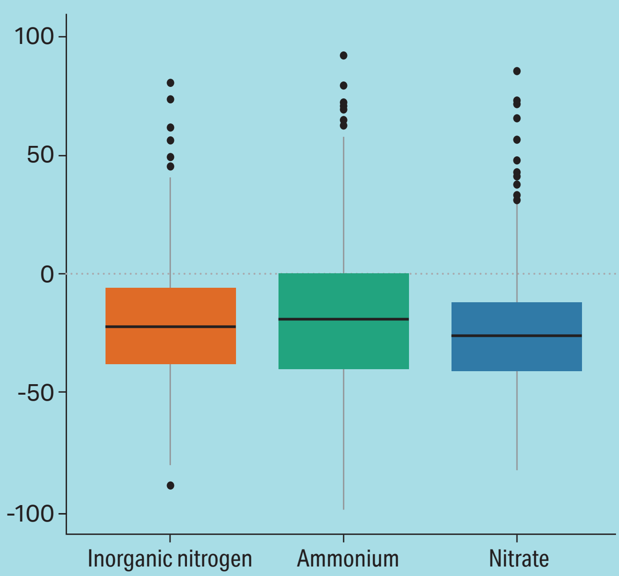


▶ Relative change in throughfall deposition of inorganic nitrogen at ICP Forests intensive monitoring plots between 2000 and 2015. Uncertainty is greater for those estimates that are not statistically significant.



▲ Mean throughfall deposition of inorganic nitrogen (kg ha^{-1} y^{-1}) for the period 2011–2015 based on data from 322 plots.

◀ Mean throughfall deposition of inorganic nitrogen at intensive monitoring sites for the period 2011–2015.



▲ Relative change in the rate of inorganic nitrogen deposition in throughfall (%) over the period 2000–2015 based on data from 200 plots. (Trends for 14 sites with more than 100% relative change are excluded).

Outlook

Under the recently updated EU National Emission Ceilings Directive, Member States have agreed to reduce emissions of several important air pollutants – including ammonia (by 16%) and nitrogen oxides (by 43%) – by 2030, compared to levels in 2015. Meeting these targets should result in lower nitrogen deposition to forest ecosystems. How the reductions in nitrogen deposition are distributed geographically will depend on the relative contributions from the various nitrogen-emitting sectors (e.g. road traffic, power generation, agriculture) and where these emission reductions take place.

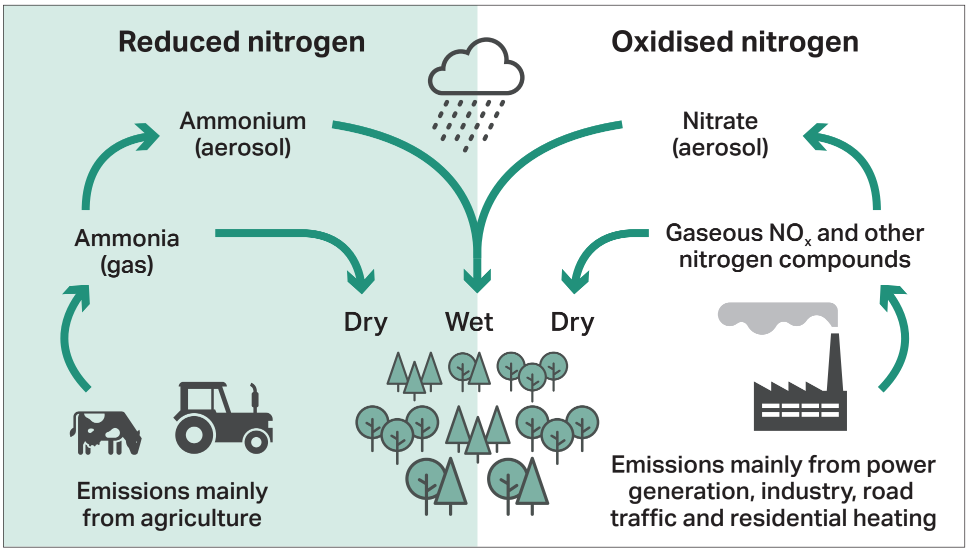
Suggested reading

Bobbink R, Hettelingh J-P (eds), 2011: Review and revision of empirical critical loads and dose-response relationships. Coordination Centre for Effects, National Institute for Public Health and the Environment (RIVM), Bilthoven, Netherlands.

CLRTAP, 2017. Mapping critical loads for ecosystems, Chapter V of Manual on Methodologies and Criteria for Modelling and Mapping Critical Loads and Levels and Air Pollution Effects, Risks and Trends. Accessed 1 March 2018.

Sutton MA et al., 2011: The European Nitrogen Assessment: sources, effects and policy perspectives. Cambridge University Press.

Waldner P et al., 2014: Detection of temporal trends in atmospheric deposition of inorganic nitrogen and sulphate to forests in Europe. Atmospheric Environment, 95:363-3741.



Simplified view of the major atmospheric transfer pathways for inorganic nitrogen between emission source and deposition to forests

Interpreting the results

This ICP Forests Brief reports on the status and trends of inorganic nitrogen deposition in throughfall only. Throughfall represents the dominant share of total nitrogen deposition at most measurement sites. It does not include nitrogen taken up directly by leaves and needles in the forest canopy or organic nitrogen compounds.

The throughfall nitrogen deposition rates reported here must therefore be considered conservative estimates of the total nitrogen deposition at many ICP Forests sites.

The lichen *Lobaria pulmonaria* is very sensitive to air pollution

Key concepts

Nitrogen deposition
The nitrogen transferred from the atmosphere to the Earth's surface

Throughfall
The precipitation that reaches the forest floor after passing through the forest canopy

Critical load
A quantitative estimate of exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge

Eutrophication
The enrichment of an ecosystem by nutrients (here: nitrogen) and a variety of associated changes in ecosystem properties

Acidification
A change in the chemical composition of the soil that results in a decrease in soil pH. It can be caused by the deposition of acidifying substances such as sulphur oxides and nitrogen compounds. In acidified soil, toxic aluminium can be released and important nutrients can be leached, impairing tree growth and vitality

United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution (Air Convention) International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests)

The data underlying this Brief were collected through ICP Forests. Monitoring sites are maintained by the ICP Forests member states and a wide range of environmental parameters and ecosystem responses are regularly assessed. See ICP Forests Brief #1 for further details. Data from Sweden were kindly provided by the Swedish Throughfall Monitoring Network (SWETHRO).

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