Critical Nitrogen Loads for N sensitive Forest Communities

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Project Scope

- Throughout Germany, experts estimate about three to four times more nitrogen being introduced into forests than is compatible with forest ecosystems.
- Increased N input imperils the functionality of forest ecosystems (e.g., eutrophication, suppression of N sensitive plant species, development of nutrient imbalances, increased N leakage to groundwater).
- The project aims to improve the data on critical N loads (N_{crit}) for forests. By this, we will provide an improved basis for the planning of measures and their enforcement under immission control legislation in order to protect N sensitive forest communities from further degradation.

Monitoring Plots and Spatial Scales

Critical N loads are estimated for forest areas in Baden-Württemberg at three spatial scales, which differ in their level of information concerning SMB terms:

1. **ICP-Forest Level II core plots** with long-term data on deposition, soil nutrient pools, soil water and nutrient fluxes, soil gas fluxes and N uptake;
2. **FFH areas of ten N sensitive forest communities** with detailed data on vegetation changes, large-scale data on deposition and soil solid phase and short-term observations on soil-water concentrations (Fig. 1);
3. **Further N sensitive forest communities** without on-plot measurements

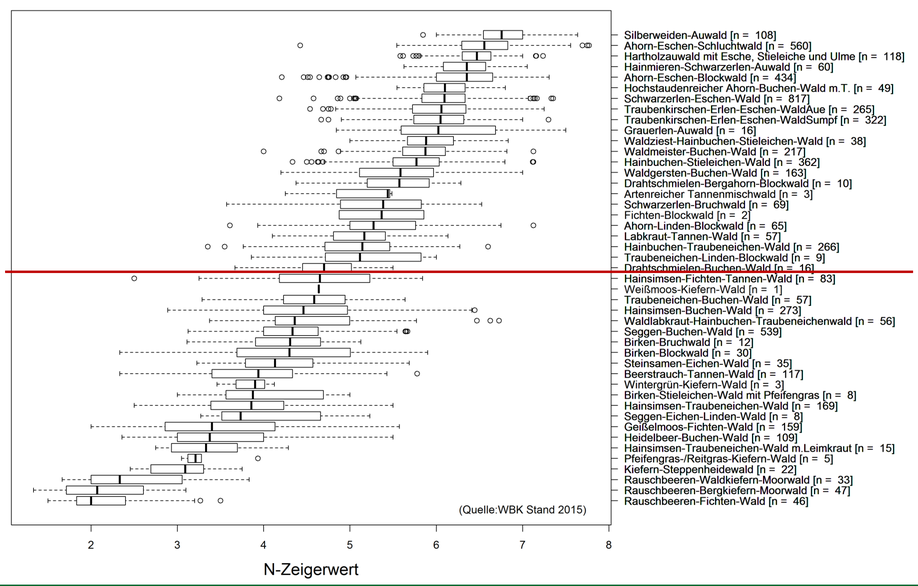


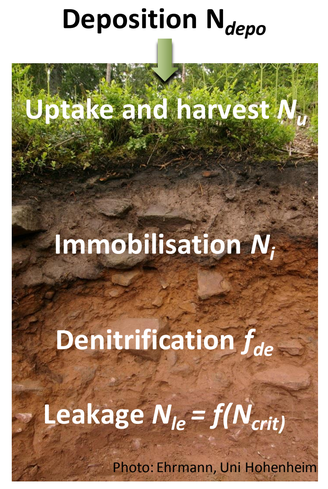
Fig. 1: Mapped Ellenberg N indicator values of the forest communities in Baden-Württemberg; forest communities below the red line are investigated by the project.

Method: Simple Mass Balance

- To estimate critical loads for various N sensitive forest communities, the approach of the Simple Mass Balance (SMB, ARGE StickstoffBW 2014) is applied:

$$CL_N = N_i + N_u + \frac{N_{le}}{1 - f_{de}}$$

- To prevent further degradation of N sensitive forest communities, deposition must be lower than CL_N.
- Data availability for the individual SMB terms depends on the spatial scale under consideration:



	ICP-Forest core plots	FFH areas	Further forest communities
Deposition	Measured N concentration in rainfall and rainfall amount	Regionalisation and transfer functions based on Level II measurements	
Uptake	Measured tree growth and understorey abundance	Measured tree dimensions and understorey abundance, transfer functions for tree growth (National Forest Inventory data)	Transfer functions for tree stock, understorey abundance and tree growth (National Forest Inventory data)
	Transfer functions for N content of tree compartments	Transfer functions for N content of tree compartments	
	N uptake of understorey and natural regeneration with PhytoCalc		
Immobilisation	Transfer functions from National Forest Soil Inventory (NFSI) data		
Denitrification	Measured soil gas N_2O concentrations, modelled gas fluxes	Estimation of N_2O fluxes from Nmin measurements and water model	Transfer functions for Nmin, rules for N_2O fluxes from water model
Leakage	Measured soil water N concentrations	Measured proxies for soil water N concentrations (Nmin, C/N ratio)	Regionalised proxies for soil water N concentrations (from NFSI data)
	Modelled (calibrated) water fluxes	Modelled (uncalibrated) water fluxes	

Results

N deposition and leakage

- N deposition under spruce around two times higher than under beech (Fig. 2).
- Negligible N leakage from all beech sites.
- High N leakage from spruce site, especially in highly conductive soils (HD, CO). Spruce sites without N leakage are sites with inhibited vertical water flow.

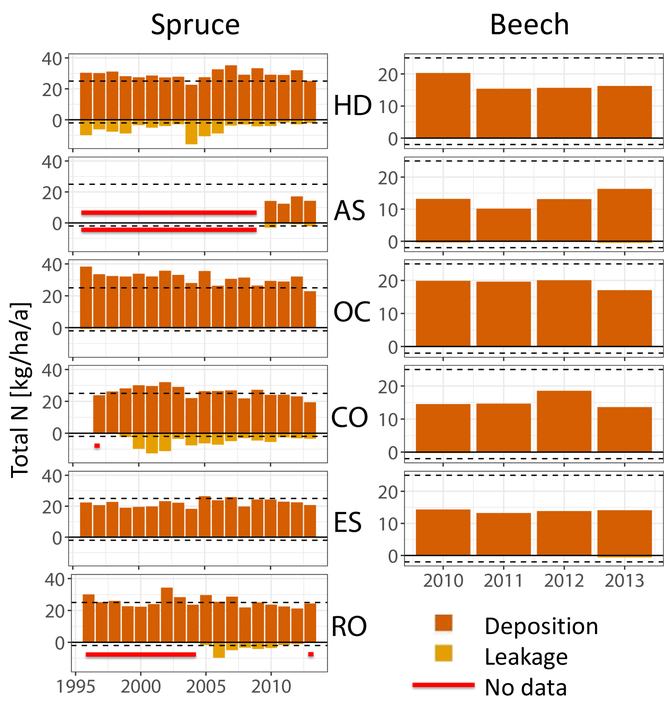
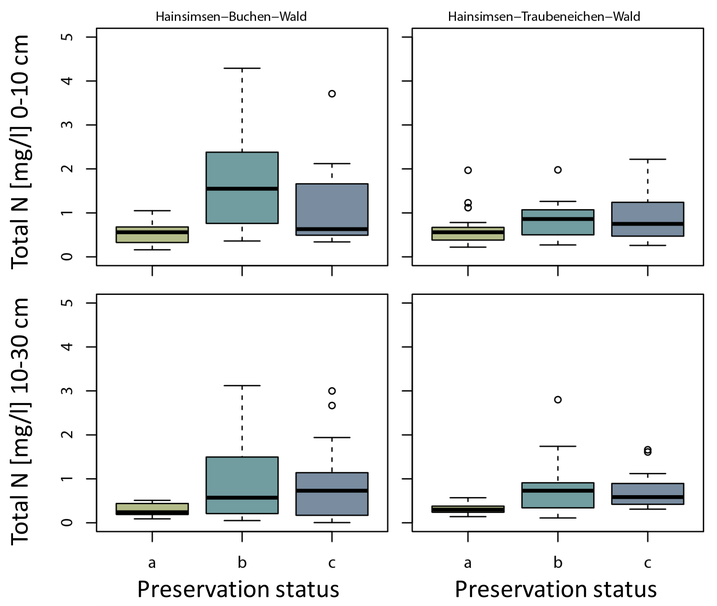


Fig. 2: Annual total N input and leakage at the ICP-Forest core plots. Dashed lines: critical values for N deposition (25 kg N/ha/a) and N leakage (2 kg N/ha/a) (Gundersen et al. 2006).

Soil water N concentrations



- Soil water N concentrations are lower in FFH areas with better N-related preservation status (class a).
- No clear differentiation of soil water N concentrations between preservation status b and c.

Fig. 3: Soil water N concentrations of 18 FFH sites (3 sites per forest community and preservation status), sampling around monthly, depending on rain events.

Soil N_2O concentrations

- Microbial metabolism releases gaseous denitrification products.
- High concentrations of N_2O in the soil gas phase are observed mainly during frost and thaw periods and during rewetting after pronounced dry spells (Fig. 4).

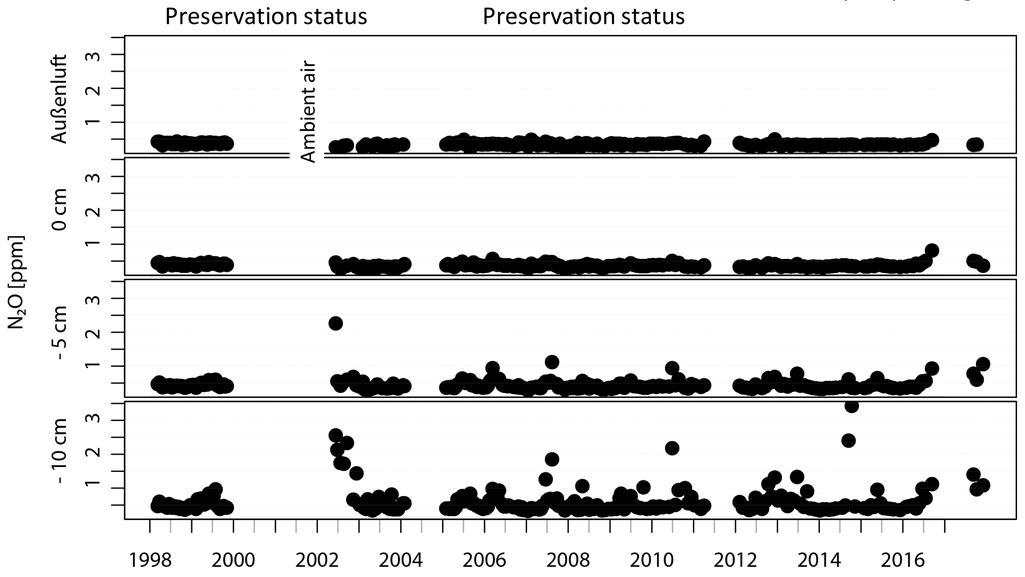


Fig. 4: N_2O concentrations in the soil gas phase at the ICP-Forest core site Ochsenhausen (spruce stand).

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References: ARGE StickstoffBW. 2014. Ermittlung standortspezifischer Critical Loads für Stickstoff-Dokumentation der Critical Limits und sonstiger Annahmen zur Berechnung der Critical Loads für bundesdeutsche FFH-Gebiete, Fachdokumentendienst Umweltbeobachtung, ID U26-S7-N12, 187 pp.; Gundersen et al. 2006. Leaching of nitrate from temperate forests effects of air pollution and forest management. Environmental Reviews, 14(1), 1-57.