Project Database of ICP Forests
PROJECT DESCRIPTION

PROJECT INFORMATION

Project title: Evaluation of relations between atmospheric deposition, soil solution chemistry and tree condition

Project ID: 80

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The aim of the project is to gain knowledge on the relations between exposure of forests to atmospheric deposition and ecological effects related to acidification and eutrophication. The objective of the study is to explore relation between actual deposition, exceedance of critical loads, exceedance of critical limits in soil solution and the tree response variables such as foliar nutrient contents and ratios, defoliation, and discoloration or visible symptoms of nutrient deficiencies based on subsets of ICP-Forests level II plots. The provided results will improve the knowledge basis of future studies aiming at establishing cause-effect relationships.

The atmospheric deposition of sulphur (S) and nitrogen (N) compounds affects forest ecosystems through several processes. Enhanced N supply may stimulate the production of above-ground biomass, but nutrient deficiencies or imbalances relative to N may arise, and sensitivity to frost, insects, and fungi may increase. When N availability exceeds the capacity of the ecosystem to retain N, increased nitrate leaching from the rooting zone occurs. Nitrate (NO3-) leaching contributes to the acidification of the soil and soil solution, as it is balanced by the concomitant leaching of base cations (BC). Sulphate (SO42-), as a strong acid, mobile anion, has a similar acidifying effect on the soil. As a further consequence of soil acidification, aluminium (Al) can be mobilized from the soil complex and have adverse effects on fine roots. Both losses in base cations through leaching and the toxic effect of aluminium on root uptake may further contribute to an unbalanced mineral nutrition of the trees.
The long-term effects of atmospheric deposition can be assessed using the concept of “critical loads” and “critical levels” (CL). These critical values are defined as a quantitative estimate of an exposure to loads or levels below which significant harmful effects on specified sensitive elements of the environment do not occur according to current knowledge (Nilsson and Grennfelt 1988). The (Ca+Mg+K)/Al molar ratio is today the most widely used criterion for estimating CL for acidity. For nitrogen, various values of N concentrations in the soil solution are directly used as criterion, depending on the effect that

is assessed (e.g. nutrient imbalances, elevation NO3- leaching or enhanced sensitivity to frost and fungal diseases).
The ICP Forests dataset provides a unique opportunity to assess, on a large scale and based on a large number of sites, whether the exceedance of critical loads and levels is associated with the deterioration in the health and vitality of the trees (e.g. decreased growth, increased defoliation, leaf yellowing, decreased foliar nutrient concentrations).

The project will explore the relation between the tree response (defoliation, foliar nutrient concentrations and ratios) and atmospheric deposition, exceedances of critical loads, or threshold values in the soil solution (e.g. pH, nitrate, Al, base cations). Rather than using the total Al concentration, as done until now, more meaningful molar BC/Al ratios will be calculated on the basis of the inorganic toxic Al species only. Available measurements of labile Al or values modelled on the basis of pH, total Al and dissolved organic carbon (DOC) will be used.
The main statistical methods will include the analysis of the distribution of variables, correlation matrices, and regressions with different techniques, including e.g. general linear models and partial least square (PLS) regression.

The data that will be used in this project are the pH and concentrations of base cations, DOC, Al, sulphate, ammonium and nitrate in throughfall (plus precipitation volume in order to be able to calculate fluxes) and in soil solution, foliar nutrient concentrations, and degree of defoliation. Foliage yellowing, as an indicator of nutrient deficiencies (e.g. magnesium), would provide valuable information, but the validity of this indicator across all European countries may be questionable due to poor calibration between countries. Tree growth would also be an extremely valuable indicator, but it can only be used when it is quantified relative to a reference value (expected e.g. after yield tables) in order to assess possible detrimental effects of deposition or unfavourable BC/Al or N values in the soil solution. Main focus will be on recent data within the same time window (e.g. 2005 - 2009). Further needed data include general information on the ICP-Forests plots (including e.g. altitude, tree species, age of the forest stand, soil data). The C/N ratio of the forest topsoil, if available, would also provide useful indications on the nitrogen status of the stand.