Critical Nitrogen Loads in nitrogen-sensitive Forest Associations – Results from Baden-Württemberg, south-western Germany

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Abstract

On the background of ongoing high nitrogen deposition this research aims to explore correlations between soil nitrogen content and changes in the understory vegetation of nitrogen-sensitive temperate forests. A database for the definition of critical nitrogen limits was created through the simultaneous assessment of vegetation, soil data and site-specific variables in nitrogen-sensitive forest associations. Based on multivariate analyses, differences in the sensitivity of different forest types are revealed and suggestions for empirically deduced critical limits are made.

Keywords: Nitrogen deposition, forest floor vegetation, critical limits

1. Background

Eutrophication caused by atmospheric nitrogen deposition still presents a major challenge for nature conservation in the 21st century. Although deposition has declined since the 1980s, deposition rates in forests extensively exceed critical loads (Andreae *et al.* 2016). These are defined as threshold values for atmospheric deposition, deposition permanently exceeding these values results in negative effects on the ecosystem, e.g. altered soil dynamics or shifts in species composition towards more nitrophytes (Bobbink *et al.* 2010). One of the variables determining critical loads are vegetation-specific critical limits, which are defined analogous to critical loads as threshold values for nitrogen concentrations in the soil solution.

The effects of nitrogen deposition on forests deserve particular attention due to their biological and structural complexity. Reliable empirical critical loads are only available for broad vegetation classes such as deciduous or coniferous forests. It is however likely that different forest associations, depending on their typical site conditions such as soil acidity and water availability, differ noticeably in their nitrogen sensitivity. As such, it is crucial to study the consequences of nitrogen discharges on more specific forest types in order to protect endangered ecosystems.

2. Aim and Methods

The project aims to improve the data base for the definition of critical loads of forests and to derive suggestions for differentiated critical limits based on the sensitivity of the vegetation. We simultaneously assessed vegetation, soil data and site-specific variables in ten nitrogen-sensitive forest associations in south-western Germany. To establish a distinct value for each forest type, a gradient ranging from intact forests, without any visible effect of surplus N (Fig. 1a), to forests which are already characterized by a high proportion of untypical and nitrophilous plants (Fig. 1c) was covered.

Fig. 1: Forest floor vegetation of Luzulo-Quercetum forests across the nitrogen gradient.

3. Results

The vegetation in the forest associations differed distinctly in their mean Ellenberg N indicator values, highlighting their varying nutrient requirements and thus different sensitivity to nitrogen input. In most of the deciduous and coniferous forest associations on acidic soil a close relationship between the C:N ratio of the upper soil layer and the nitrogen-related vegetation status was found. However, this could not be confirmed for deciduous forests on base-rich soils. Varying relationships between other soil and environmental variables and the vegetation composition were also identified. Based on the results multivariate models were used to calculate nitrogen thresholds for different vegetation parameters and to suggest critical limits.

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References

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