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The significance of fertilisation experiments for understanding the impacts of atmospheric nitrogen deposition on the forest carbon cycle

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The current discussion on the role of nitrogen deposition on the forest carbon cycle is focussed on determining the likely system response (in terms of added or reduced C sequestration) to a unit addition of nitrogen, i.e., dC/dN (kg C/kg N). A potential source of valuable information is given by existing fertilisation experiments, which we will review in this presentation.

The literature on fertilisation consists of the order of 300 separate experiments worldwide, of which about 60 to 70 have been conducted in forests. However, for a number of reasons, only a few experiments have been conducted in such a manner that they can provide useful information to understand the impacts of N deposition. Here we highlight two main issues. The first one relates to the high and infrequent doses typically applied during fertilisation studies, which differ from the low and chronic doses prevailing under ambient deposition. A small subset of the existing studies can be used to enable the extrapolation of the results from high but infrequent doses to low but chronic additions. The second issue is that only a handful of the existing experiments have been carried out by spraying a nitrogen solution over canopies. Our knowledge principally relies on the results obtained via traditional ground fertilisation experiments. This presents a potential problem because atmospheric deposition filters through the canopies whereas ground applications exclude direct canopy N processing.

Overall, we find that: a) the dose applied has a crucial effect in determining the response, in such a way that with high doses the values of dC/dN are lower (or even change sign). Therefore, current estimates of the impacts of N deposition based on fertilisation studies alone are generally too low, because this non-linear effect was not taken into account. Here, we provide a method by which a correction factor can be derived for experiments conducted at unrealistically high doses. b) There is a large variability among studies in the system response to N addition. In some cases this variability can be explained by the limiting action of other nutrients; c) for a case study of one species (Sitka spruce) in one country (the United Kingdom), the results of a direct canopy fertilisation experiment (Deepsyke) were compared against those obtained in a number of ground fertilisation studies, to highlight the potential importance of canopy N processing. At Deepsyke, a much increased tree C accumulation was observed compared to other ground fertilisation studies (by about 65%, a percentage similar to atmospheric N retention by Sitka spruce canopies), again suggesting that current estimates should be revised upwards.

Further analyses of the existing experiments coupled with modelling can provide valuable information on the effects of N deposition on the forest C cycle.